
AQUATIC SYSTEMS IN THE MACKENZIE
PORCUPINE DRAINAGES
VOL II

ECOLOGICAL STUDIES OF AQUATIC SYSTEMS IN THE MACKENZIE-PORCUPINE DRAINAGES IN RELATION TO PROPOSED PIPELINE AND HIGHWAYS DEVELOPMENTS

VOLUME II

APPENDICES

by

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The data for this report were obtained as a result of investigations carried out under the Environmental-Social Program, Northern Pipelines, of the Task Force on Northern Oil Development, Government of Canada. While the studies and investigations were initiated to provide information necessary for the assessment of pipeline proposals, the knowledge gained is equally useful in planning and assessing highways and other development projects.

LIST OF APPENDICES

APPENDIX I

Station Locations for 1971-72
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Appendix I

Station Locations - 1971 and 1972

A. Yukon - All stations listed below were sampled in 1971. Those with abbreviations were sampled in 1972 as well. Only one river was added in 1972: Joe Creek.

1. Porcupine River - N. slope stations

Station	Abbreviation	Coordinates N	Coordinates W
Bluefish River	BR		
No. 1		67°04'	140°50'
No. 2		66°58'	140°70'
No. 3		66°52'	140°40'
No. 4		67°03'	140°30'
No. 5		67°14'	140°33'
No. 6		67°24'	140°11'
Br. 1		67°29'	140°15'
Caribou Bar Creek	CC		
No. 7		67°28'	140°33'
CC 1		67°28'	140°33'
CC 2		67°32'	140°35'
CC 3		67°36'	140°30'
CC 4		67°37'	140°30'
CC 5		67°38'	140°28'
CC 6		67°38'	140°27'
CC 7		67°39'	140°27'
CC 8		67°40'	140°26'
CC 9		67°38'	140°42'
CC 10		67°39'	140°44'
CC 11		67°38'	140°28'
Driftwood River	DW		
No. 8		67°57'	137°48'
No. 9		67°43'	138°20'
No. 10		67°38'	138°25'
DW 1		67°34'	138°30'

Lord Creek	LC		
No. 11		67°37'	139°10'
No. 12		67°19'	139°09'
No. 13		67°10'	139°34'
LC 1		67°37'	139°34'
Eagle River	ER		
No. 34		66°19'	136°30'
No. 35		66°37'	137°03'
ER 1		67°17'	137°10'
Rat River			
No. 37		67°19'	136°40'
Bell River	BE		
No. 38		67°33'	136°42'
No. 39		67°42'	137°29'
No. 40		67°54'	136°54'
No. 41		68°01'	136°59'
No. 43		67°20'	137°12'
No. 119		67°21'	137°30'
BE 1		67°17'	137°45'
BE 2		67°18'	137°07'
BE 3		67°42'	137°29'
Fishing Branch			
No. 25		66°33'	139°23'
No. 26		66°25'	139°25'
Miner River			
No. 27		66°09'	138°52'
Whitestone River			
No. 32		66°24'	138°16'
No. 33		66°04'	137°56'
Cody Creek			
No. 24		66°46'	139°02'
Pine Creek			
No. 29		67°00'	139°08'
No. 31		66°58'	138°09'
Johnson Creek (Porcupine)			
No. 30		67°12'	139°00'
Berry Creek			
No. 21		67°31'	137°55'
No. 22		67°37'	137°48'
Rat Indian Creek			
No. 23		67°35'	138°20'

Porcupine River	PR		
No. 28		66°32'	138°25'
No. 36		66°52'	137°30'
No. 42		67°08'	137°32'
No. 20		67°17'	137°53'
No. 44		67°27'	137°49'
No. 45		67°34'	138°35'
No. 46		67°33'	139°13'
No. 116		66°26'	140°42'
No. 118		67°29'	138°05'
No. 120		67°01'	137°29'
PR 1		67°28'	140°34'
PR 2		67°35'	139°50'
PR 3		67°37'	139°34'
PR 4		67°34'	138°30'
PR 5		67°17'	137°45'
Joe Creek	JC		
JC 1		67°35'	139°50'
Old Crow River	OC		
No. 14		67°55'	140°29'
No. 15		67°54'	140°50'
No. 16		67°56'	140°55'
No. 17		68°09'	140°53'
No. 18		68°24'	139°43'
No. 19		68°09'	139°58'
No. 47		67°38'	139°47'
No. 55		67°50'	139°50'
No. 56		68°04'	139°34'
No. 57		67°57'	139°10'
No. 58		68°10'	138°17'
No. 59		68°22'	138°51'
No. 60		68°13'	138°58'
No. 117		67°43'	139°49'
Old Crow River			
OC 1		67°35'	139°50'
OC 2		68°10'	140°45'
OC 3		68°12'	140°45'
OC 4		68°11'	138°54'
OC 5		68°11'	137°53'
Firth River			
No. 48		69°03'	140°28'
No. 49		69°12'	139°47'
No. 50		69°23'	139°30'
Babbage River			
No. 51		69°08'	138°20'

No. 53	68°57'	138°26'
No. 54	68°51'	138°56'
Blow River		
No. 52	68°50'	137°08'

2. Peel River and other NWT drainages

Stony Creek		
No. 62	67°20'	135°07'
No. 63	67°22'	135°29'
No. 99	67°18'	135°40'
Vittrekwa River		
No. 64	67°11'	135°17'
No. 65	67°10'	135°02'
No. 66	67°07'	135°25'
No. 100	67°05'	135°48'
No. 101	66°51'	135°37'
Road River		
No. 68	66°42'	135°15'
No. 69	66°39'	135°08'
No. 102	66°34'	135°38'
Trail River		
No. 88	66°24'	134°58'
No. 89	66°38'	134°37'
No. 103	66°28'	135°23'
Caribou River		
No. 83	66°28'	134°10'
No. 84	66°19'	134°22'
No. 87	66°13'	134°45'
No. 98	66°15'	134°30'
No. 104	66°15'	135°04'
Mountain Creek		
No. 85	65°55'	135°06'
No. 97	66°03'	135°12'
Satah River		
No. 90	66°58'	134°35'
No. 105	66°56'	134°16'
Brown Bear Creek		
No. 82	66°42'	134°11'
Snake River		
No. 91	65°59'	134°12'

Solo Creek		
No. 93	65°54'	134°16'
Noisy Creek		
No. 94	65°53'	134°50'
Bonnet Plume		
No. 95	65°50'	134°53'
Wind River		
No. 96	65°48'	135°18'
Sainville River		
No. 72	66°30'	133°40'
No. 74	66°33'	133°18'
No. 79	66°03'	132°28'
No. 80	66°16'	133°07'
No. 81	66°21'	133°26'
Cranswick River		
No. 78	66°05'	132°09'
Lower Beaver River		
No. 75	66°40'	132°59'
Weldon Creek		
No. 70	66°26'	133°42'
No. 76	66°16'	132°10'
Ontaratue River		
No. 77	66°15'	131°40'
No. 109	66°24'	131°08'
No. 110	66°36'	130°26'
No. 111	66°28'	130°27'
Ramparts River		
No. 107	65°59'	130°30'
No. 108	66°05'	130°57'
No. 112	66°23'	130°42'
No. 113	66°13'	131°10'
Hume River		
No. 106	65°48'	129°20'
Arctic Red River		
No. 71	66°22'	133°42'
No. 73	66°30'	133°40'
No. 114	66°10'	132°25'
No. 115	66°40'	133°07'

Peel River			
No. 61		67°23'	134°57'
No. 67		66°50'	134°57'
No. 86		65°55'	135°06'
No. 92		65°59'	134°12'

B. Mackenzie Delta - Asterisks (*) indicate stations sampled only in 1971.

1. Channels, creeks, and rivers

Aklavik Channel	AC 1	68°13'	134°44'
Campbell Creek	CC 1	68°17.7'	133°15'
	CC 2	68°17.4'	133°15'
East Channel	* EC (Stony Beach)	68°36'	134°00'
	EC 1	68°17'	133°46'
	EC 3	68°29'	133°50'
	EC 4	68°38'	134°03'
	EC 6	68°01'	133°54'
	EC 7	68°58'	134°37'
	EC 8	69°11'	134°15'
	* EC 9	67°53'	134°00'
	EC 10	68°21'	133°43'
Gullies' Channel	GC 1	68°30.7'	133°59'
Jamieson Channel	JC 1	68°37'	135°22'
	* JC 2	68°26'	135°04'
Main Channel	MC 1	68°38'	134°11'
	* MC 3	68°15'	134°23'
	* MC 4	68°01'	134°28'
	* MC 5	67°53'	134°21'
Napoiak Channel	NC 1	68°36'	134°57'
	* NC 2	68°26'	134°24'
Peel Channel	* PC 1	68°11'	135°07'
	* PC 2	68°01'	135°07'
	* PC 3	67°53'	134°52'
Rengleng River	R 1	67°45.5'	133°52'
	R 2	67°45.5'	133°52'
	R 3	67°45.5'	133°52'
	R 4	67°45.5'	133°52'
West Channel	WC 1	68°37'	135°44'
	WC 2	68°25'	135°25'
	WC 3	68°15'	135°03'

Hope Channel	* 16	69°13'	135°36'

2. Lakes

East Channel	EC 2	68°29'	133°50'
Wolverine Lakes Area	L 1	68°46'	134°45'
	* L 2	68°46'	134°48'
Schooner Channel Area	L 3	68°18.5'	134°31'
	L 4	68°20'	134°31'
	* L 4 C	68°20'	134°31'
	LC 4	68°20'	134°31'
Aklavik Channel Area	L 5	68°02'	134°55'
	* L 6	68°01'	134°49'
Peel Channel Area	L 7	67°54.5'	134°47'
Tuk Peninsula	L 11	69°16.5'	133°30'
	L 12	69°19'	132°51'
Richard's Island	Denis Lake	69°20'	134°34'
	*'Y' Lake	69°13'	134°27'
'Shell' (= Long) Lake	SL 1	68°19.5'	133°37'

3. Bays and Sea

Beaufort Sea	BS 13	69°52'	132°15'
	* BS 14	69°39'	133°04'
	BS 15	69°40'	134°56'
	BS 18	69°47'	133°00'
	* BS 19	69°47'	133°50'
	* BS 20	69°40'	133°37'
	* BS 21	69°08'	136°42'
	* BS 22	68°59'	136°40'
	* BS 23	68°58'	136°18'
	* BS 24	69°33'	135°14'
	BS 26	69°38.5'	135°11'
Kugmallit Bay	KU 4	69°28'	133°18'
	KU 5	69°34'	133°13'
	KU 6	69°35'	133°32'
	* KU 7	69°43'	134°00'
	* KU 8	69°45'	134°27'
	* KU 17	69°26'	133°40'
Shallow Bay	* SB 1	68°48'	135°36'

C. Mackenzie Mainstem

1. 1971

a) Arctic Red River Base

Station	Abbreviation	Coordinates	
Arctic Red Pond	AR	67°27'	133°43'
Babaluk Brook	BB	67°28'	133°47'
Corry Bay	CB	67°25'	133°34'
The Cardinal	CD	67°32'	133°52'
Frog Creek	FC	67°38'	134°39'
Nagle Creek	NA	67°23'	133°32'
No Name 9	N9	67°34'	134°00'
No Name 11	N11	67°26'	133°45'
No Name 15	N15	67°35'	134°03'
Pierre Creek	PE	67°20'	133°22'
Point Separation I	PSI	67°36'	134°03'
Point Separation II	PSII	67°39'	134°07'
Point Separation III	PSIII	67°47'	134°11'
Rengleng River	RG	67°48'	134°07'
Rat River	RT	67°18'	132°32'
Tsital Trein Creek	TT	67°29'	133°34'
Tree River	TY	67°15'	132°34'

b) Norman Wells, Base

Brackett River	BD	64°58'	125°27'
Bluefish Creek	BF	64°56'	125°51'
Billy Creek	BK	65°20'	127°09'
Bosworth Creek	BO	65°17'	126°52'
Carcajou River	CA	65°37'	128°43'
Christina Creek	CT	65°11'	126°25'
Canyon Creek	CY	65°13'	126°32'
Devo Creek	DC	65°24'	127°29'
D.O.T. Creek	DO	65°15'	126°40'
Francis Creek	FA	65°12'	126°28'
Great Bear River	GB	64°56'	125°33'
Goose Creek	GC	65°31'	127°38'
Helava Creek	HC	65°11'	126°26'
Little Bear River	LB	64°54'	125°55'
Lunch Creek	LN	65°34'	127°51'
Loon Creek	LO	65°14'	126°55'
Mountain River Tributary	MO	65°41'	128°53'
Mountain River	MT	65°40'	128°54'
Oscar Creek	OC	65°27'	127°27'
Prohibition Creek	PB	65°08'	126°19'

Ray Creek	RC	65°16'	127°10'
Raspberry Creek	RP	65°36'	128°19'
Slater River	SL	64°58'	126°07'
Stewart Creek	ST	65°11'	126°39'
Trapper Creek	TE	65°33'	127°54'
Vermillion Creek	VC	65°05'	126°10'

c) Fort Simpson Base

Harris River	HR	61°52'	121°19'
Jean-Marie River	JM	61°31'	120°39'
Liard River	LR		
opposite Manner's Creek		61°47'	121°12'
below Manner's Creek		61°46'	121°11'
near Gros Cap		61°50'	121°17'
Mackenzie River	MA		
above Spence River		61°33'	120°41'
below Martin Island		61°51'	121°16'
opposite Ft. Simpson		61°53'	121°22'
above Martin River		61°55'	121°31'
Manner's Creek	MC	61°46'	121°11'
Martin River	MR	61°55'	121°35'
Rabbitskin River	RR	61°47'	120°39'
Spence River	SR	61°34'	120°41'
Trail River	TR	62°06'	122°12'
Trout River	TO	61°07'	119°49'

d) Yellowknife Base

Great Bear River at the Brackett River	BD	64°58'	125°27'
Blackwater River	BT	63°57'	124°05'
Peel River	PL	67°12'	135°00'
Pettitot River	PT	60°14'	123°28'
Saline River	SE	64°18'	124°30'
Willowlake River	WL	62°42'	123°05'

2. 1972

Harris River	HR		
Station 1		61°52'	121°18'
Station 2		61°52'	121°19'
Jean-Marie River	JM		
Station 1		61°31'	120°39'
Station 2		61°31'	120°39'
Liard River	LR	61°50'	121°17'
Mackenzie River	MA	61°51'	121°16'

Martin River	MR		
Station A		61°53'	121°37'
Station B		61°53'	121°37'
Station C		61°53'	121°37'
Station 1		61°54'	121°36'
Station 2		61°55'	121°36'
Station 3		61°55'	121°35'
Poplar River	PR	61°22'	121°48'
Rabbitskin River	RR		
Station 1		61°47'	120°38'
Station 2		61°47'	120°39'
Trail River	TR		
Station 1		62°06'	122°11'
Station 2		62°06'	122°11'
Station 2a		62°06'	122°11'

Synoptic Survey Stations: Physical/Chemical Studies

Arctic Red R. (Mackenzie River)		67°27'	133°48'
Arctic Red R. (Martin House)		66°47'	133°06'
Blackwater R. (Mackenzie River)		63°57'	124°20'
Bluefish R. (Hare Indian)		66°24'	128°11'
Brackett R. (Great Bear River)		64°56'	125°27'
Flat River (South Nahanni River)		61°32'	125°24'
Great Bear River (Great Bear Lake)		65°08'	123°31'
Great Bear River (Brackett River)		64°58'	125°27'
Hanna River (Mackenzie River)		65°60'	128°45'
Hare Indian River (Mackenzie River)		66°18'	128°38'
Harris River (Mackenzie River)	61	61°52'	121°10'
Horn River (Mackenzie River)		61°31'	118°00'
Jackfish Creek (South Nahanni River)		61°09'	123°39'
Jean-Marie Creek (Mackenzie River)		61°31'	120°39'
Johnny Hoe River (Lac Ste. Therese)		64°50'	121°60'
Liard River (Ft. Liard)		60°15'	123°29'
Liard River (Mackenzie River)		61°50'	121°20'
Mackenzie River (Ft. Providence)		61°22'	117°37'
Mackenzie River (above Liard River)		61°51'	121°16'
Mackenzie River (Wrigley)		63°16'	123°37'
Mackenzie River (San Sault Rapids)		65°44'	128°35'
Mackenzie River (20 miles South Norman Wells)		65°16'	126°49'
Mackenzie River (Ft. Good Hope)		66°16'	128°39'
Mackenzie River (Arctic Red River)		67°27'	133°48'
Martin River (Mackenzie River)		61°55'	121°35'
Mountain River (Mackenzie River)		65°41'	128°50'
Peel River (Ft. McPherson)		67°27'	134°52'
Petitot River (Liard River)		60°14'	123°28'
Rabbitskin River (Mackenzie River)		61°47'	120°42'
Redknife River (Mackenzie River)		61°12'	119°23'
Redstone River (Mackenzie River)		64°11'	124°40'

Saline River (Mackenzie River)	64°18'	124°30'
S. Nahanni (Virginia Falls)	61°38'	125°48'
S. Nahanni (Clausen Creek)	61°15'	124°02'
Trail River (Mackenzie River)	62°06'	122°11'
Trout River (Mackenzie River)	61°18'	119°50'
Willowlake River (Mackenzie River)	62°39'	122°55'

Figure 1: BENTHIC STUDY AREAS 1971 AND 1972. BENTHIC MAINSTREAM SURVEY 1971. SOLUTION AND SEDIMENT CHEMISTRY SURVEY 1971 NAD 1972.

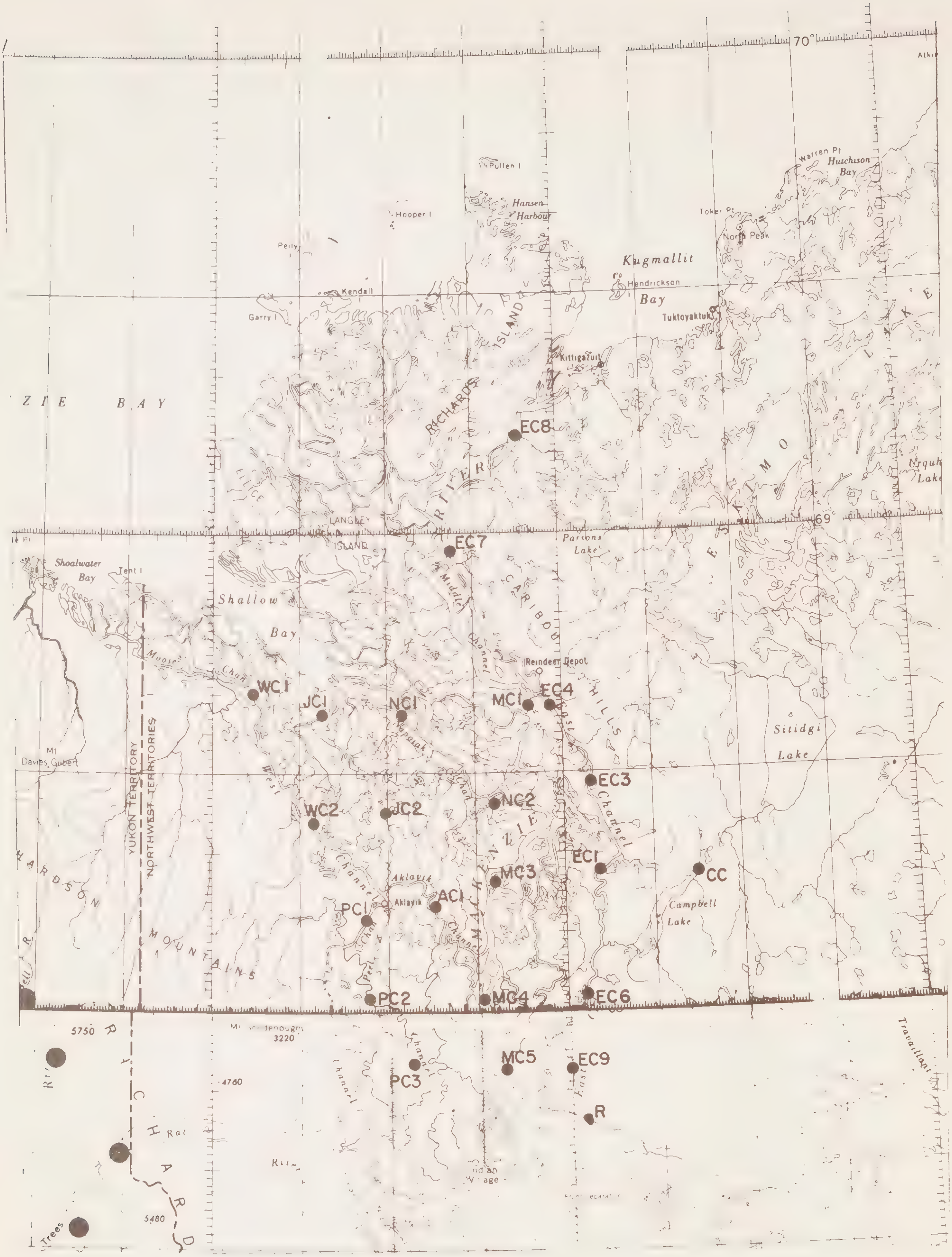


Figure 2: Mackenzie Delta stations - channels.

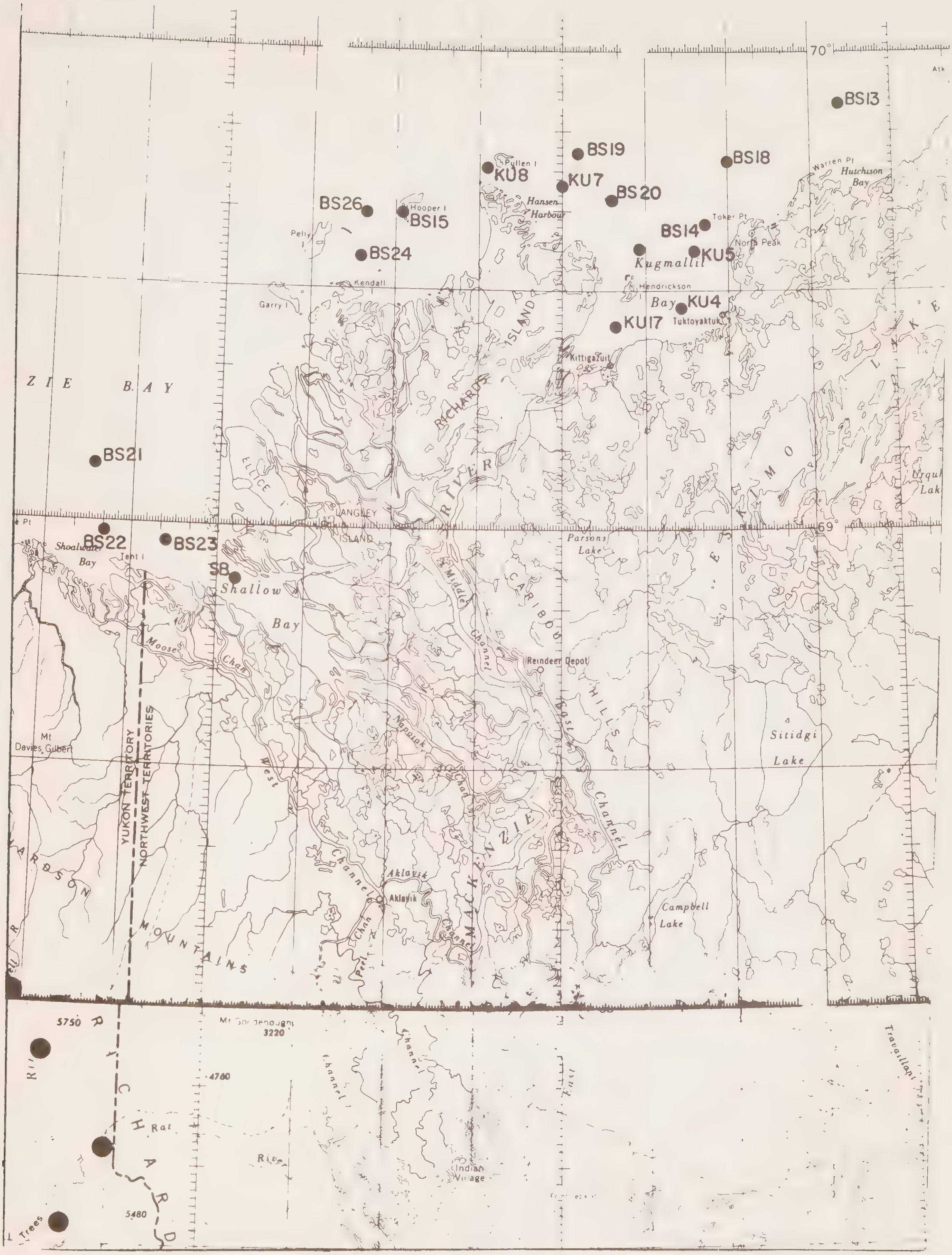


Figure 3: Mackenzie Delta stations - brackish zone.

Figure 4: Mackenzie Delta stations - lakes.

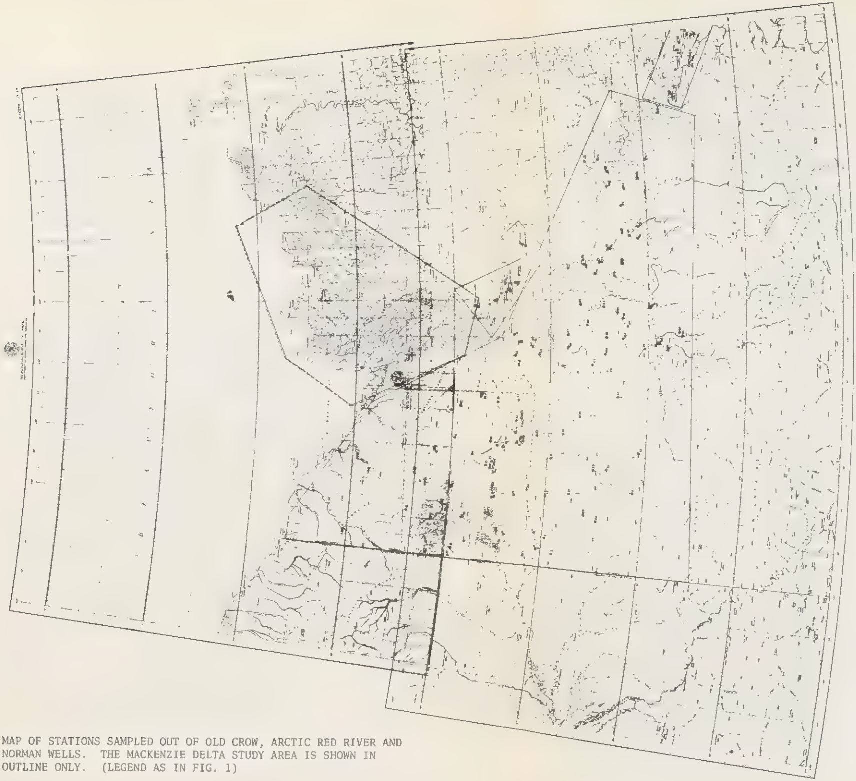


FIG. 5 MAP OF STATIONS SAMPLED OUT OF OLD CROW, ARCTIC RED RIVER AND NORMAN WELLS. THE MACKENZIE DELTA STUDY AREA IS SHOWN IN OUTLINE ONLY. (LEGEND AS IN FIG. 1)

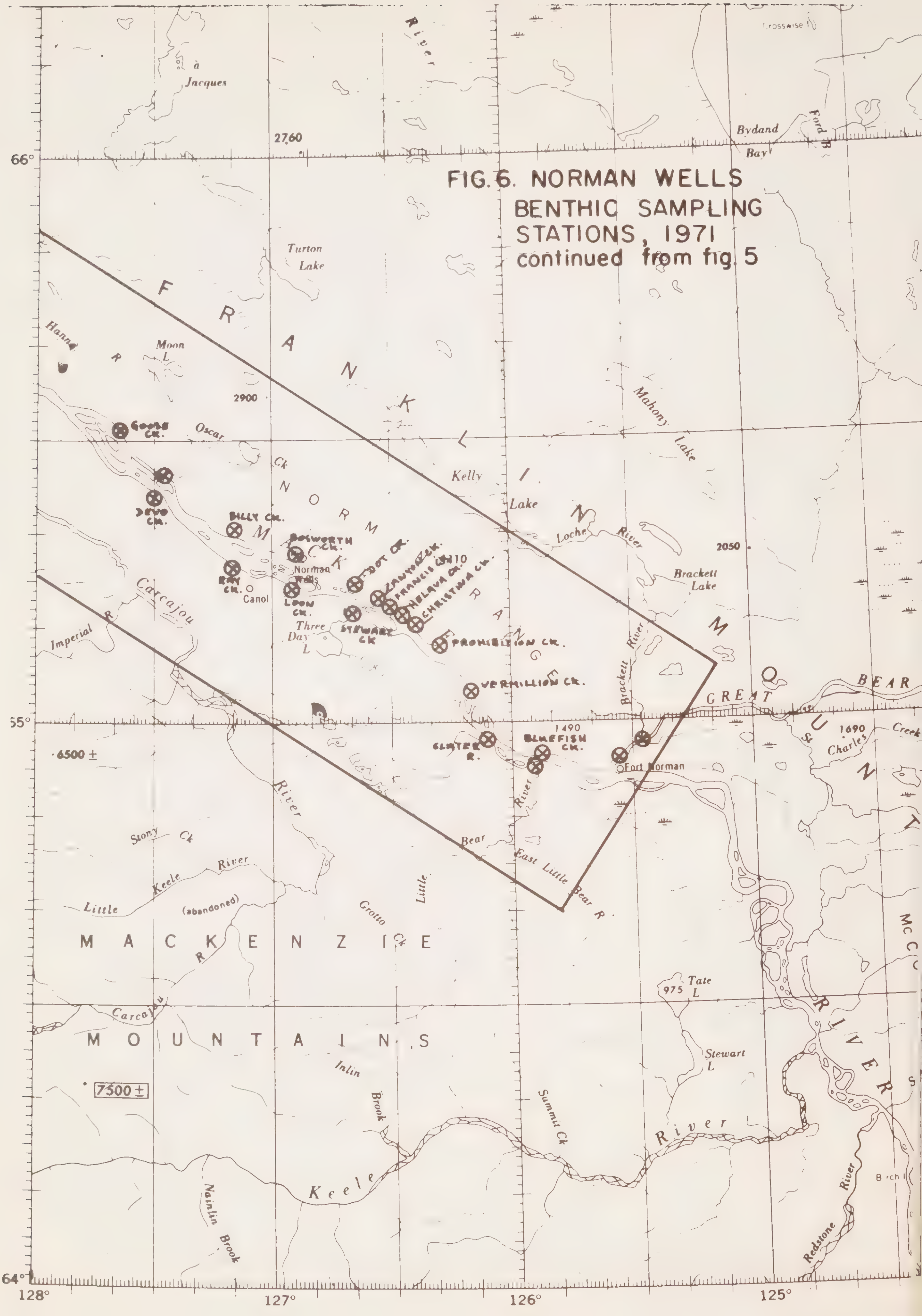


FIG. 6. NORMAN WELLS
BENTHIC SAMPLING
STATIONS, 1971
continued from fig. 5
FRANKLIN MOUNTAINS
NORMAN RANGE
MACKENZIE MOUNTAINS
GOOSE CK.
DEVO CK.
BILLY CK.
BOSWORTH CK.
Norman Wells
Canol
LOON CK.
DOT CK.
STEWART CK.
FRANCIS CK.
CHRISTINA CK.
PROHIBITION CK.
VERMILLION CK.
SLATER R.
BLUEFISH CK.
Fort Norman
GREAT BEAR
Kelly Lake
Mahony Lake
Brackett Lake
Brackett River
Loche River
Turton Lake
Moon L
Three Day L
Carcajou R
Imperial
Oscar Ck
Keele River
Little Keele River
Stony Ck
Grotto Ck
Inlin Brook
Nainlin Brook
Summit Ck
Tate L
Stewart L
Redstone River
St Charles Creek
Bydand Bay
Jacques
East Little Bear R
2760
2900
2050
1490
1690
975
6500 ±
7500 ±
66°
65°
64°
128°
127°
126°
125°

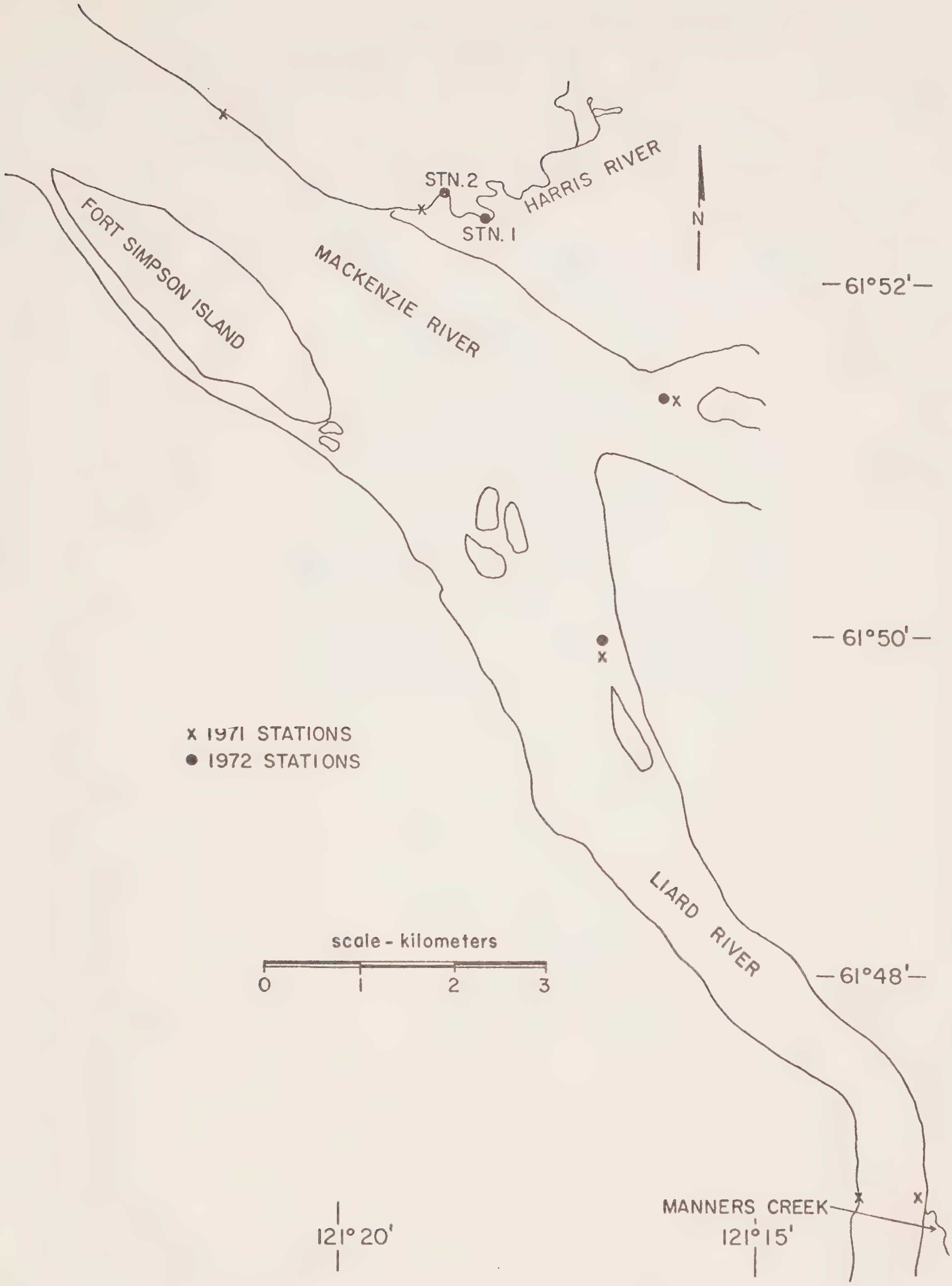


Figure 7a: Fort Simpson benthos sampling stations.

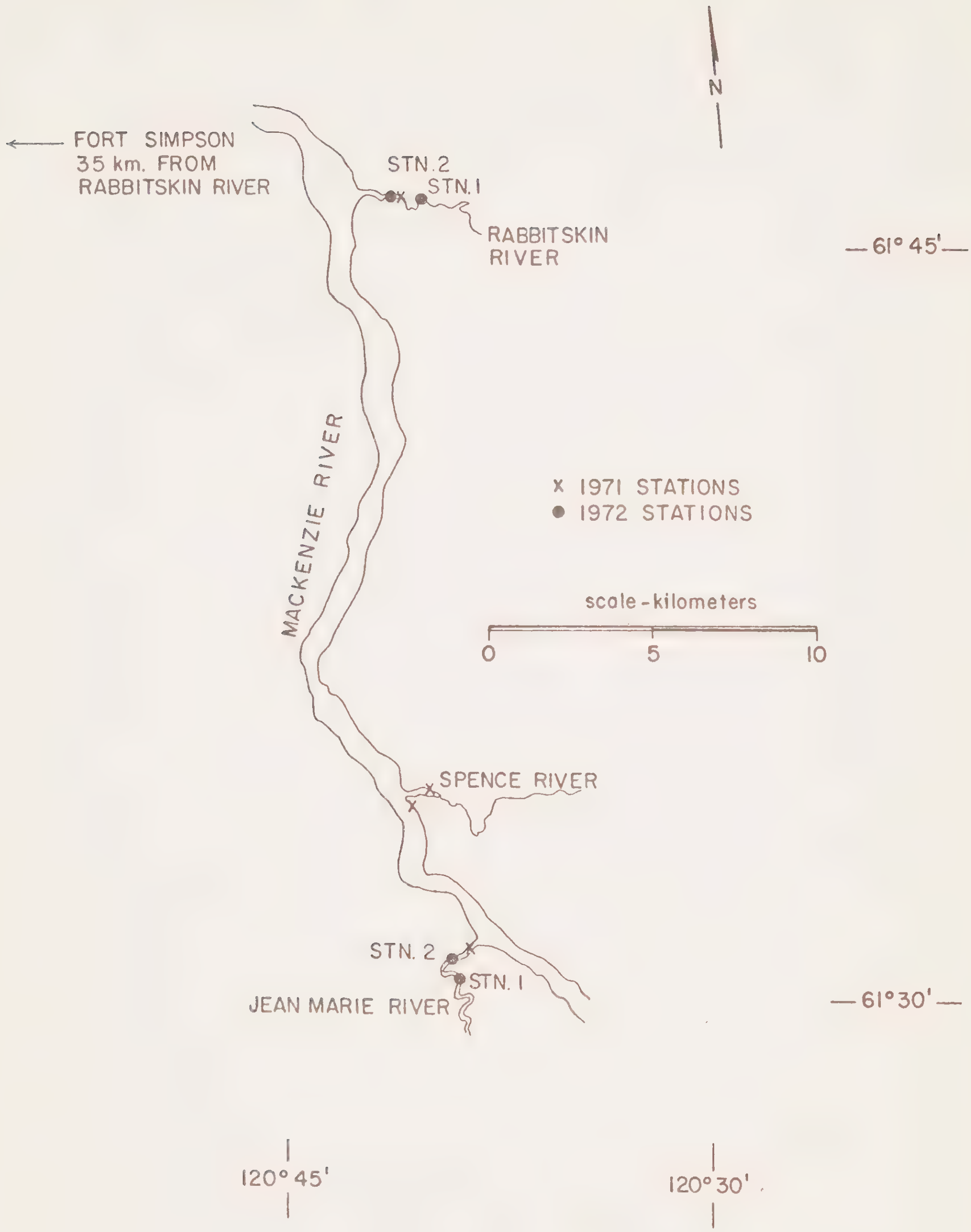


Figure 7b: Fort Simpson benthos sampling stations.

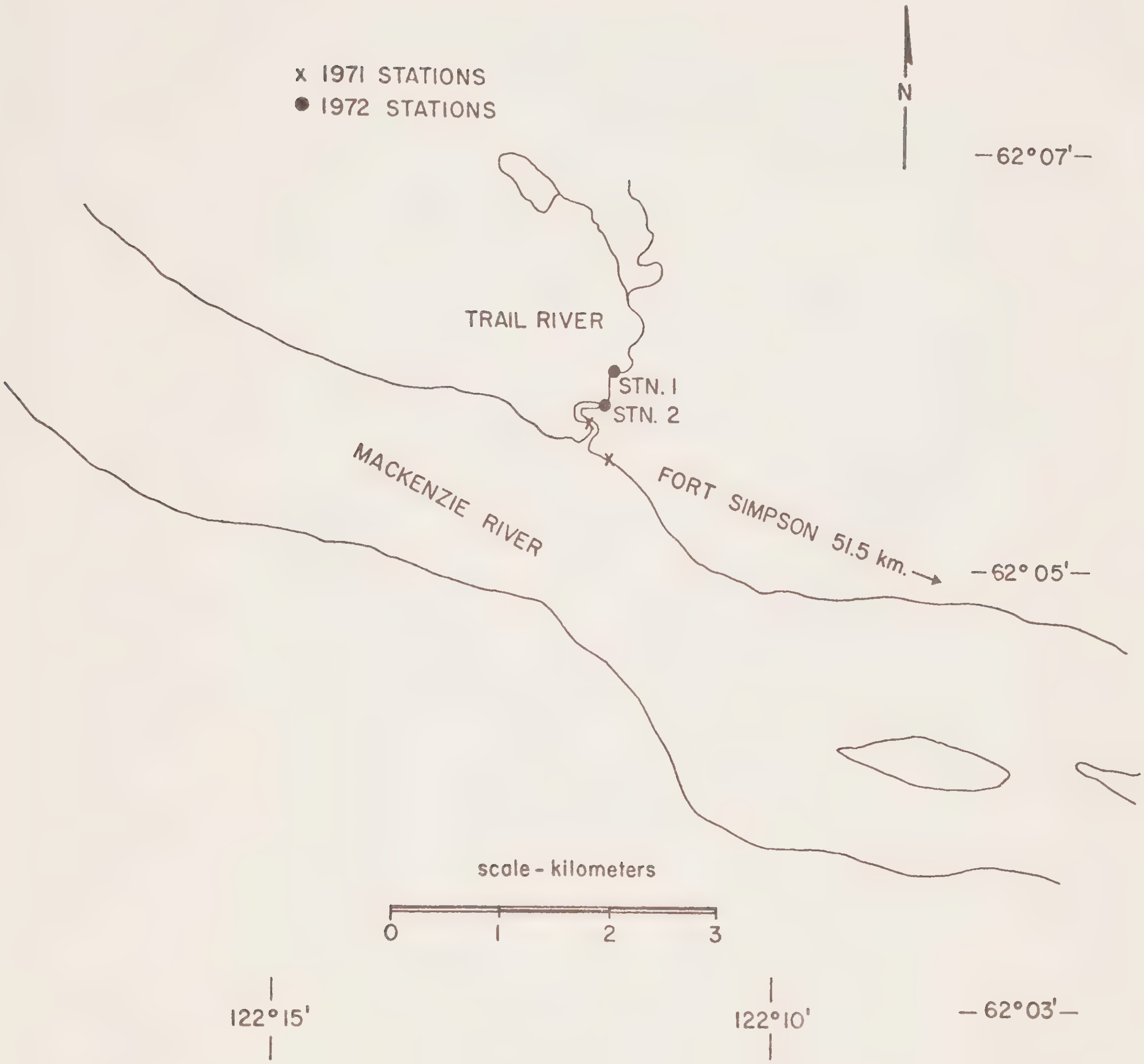


Figure 7c: Fort Simpson benthos sampling stations.

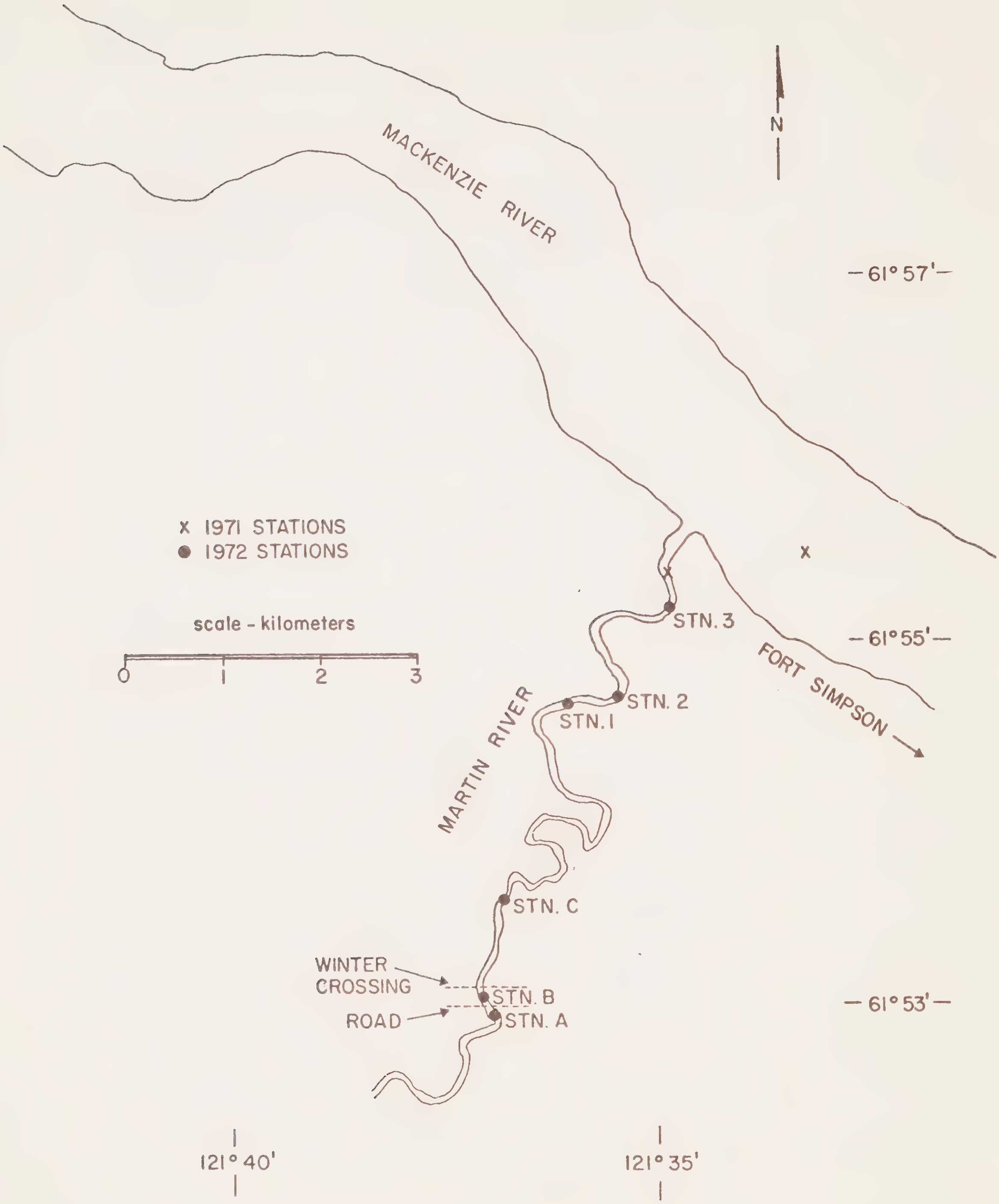


Figure 7d: Fort Simpson benthos sampling stations.

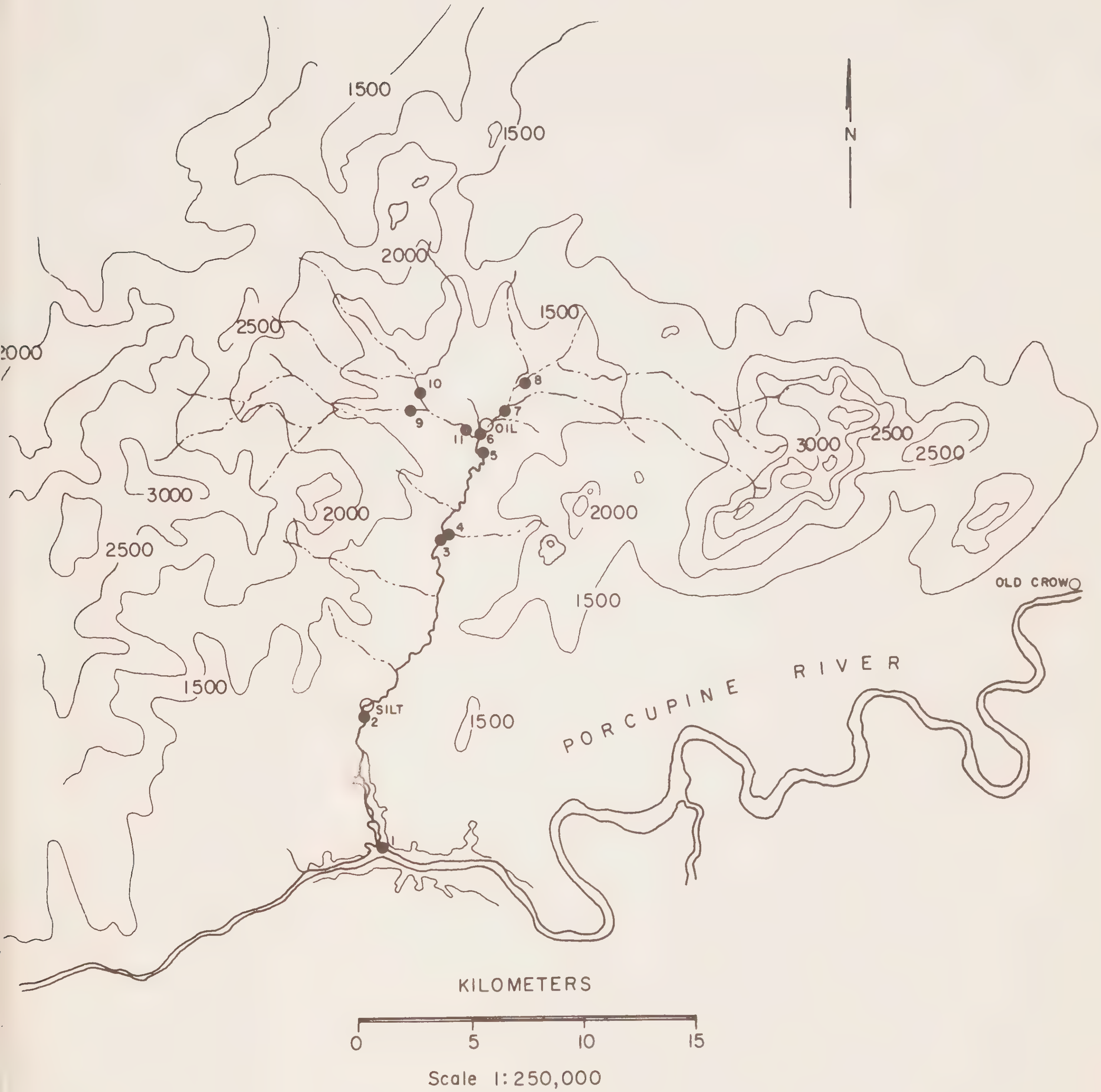


Figure 8: Map of Caribou Bar Creek stations (open circles indicate mud slide and oil spill experiment).

APPENDIX II

Temperature and Salinity Tables for the Mackenzie Delta and vicinity, 1971-72

SALINITY STATION LOCATIONS
1971 and 1972

Table I Salinity Stations, 1971 and 1972

Station	Position	
A1	133° 42' W	69° 23' N
A2	133° 48' W	69° 23' N
A3	133° 53' W	69° 23' N
B1	133° 05' W	69° 28' N
B2	133° 18' W	69° 28' N
B3	133° 30' W	69° 28' N
B4	133° 47' W	69° 28' N
C1	133° 00' W	69° 34' N
C2	133° 16' W	69° 34' N
C3	133° 27' W	69° 34' N
C4	133° 37' W	69° 34' N
C5	133° 44' W	69° 34' N
D1	132° 53' W	69° 40' N
D2	133° 11' W	69° 40' N
D3	133° 23' W	69° 40' N
D4	133° 37' W	69° 40' N
D5	133° 50' W	69° 40' N
D6	134° 07' W	69° 40' N
E1	132° 23' W	69° 46' N
E2	132° 38' W	69° 46' N
E3	133° 00' W	69° 47' N
E4	133° 21' W	69° 47' N
E5	133° 50' W	69° 47' N
E6	134° 16' W	69° 47' N
F1	134° 33' W	69° 35' N
F2	134° 43' W	69° 34' N
F3	134° 54' W	69° 32' N
F4	135° 08' W	69° 32' N
G1	134° 30' W	69° 40' N
G2	134° 44' W	69° 38' N
G3	135° 00' W	69° 36' N
G4	135° 14' W	69° 33' N
G5	135° 26' W	69° 32' N
G6	135° 36' W	69° 30' N
H1	134° 30' W	69° 45' N
H2	134° 48' W	69° 43' N
H3	135° 02' W	69° 40' N
H4	135° 17' W	69° 38' N

Table I Salinity Stations, 1971 and 1972 (continued)

H5	135° 37' W	69° 35' N
H6	135° 52' W	69° 32' N
J1	135° 34' W	69° 26' N
J2	135° 46' W	69° 22' N
J3	135° 54' W	69° 18' N
J4	136° 05' W	69° 13' N
J5	136° 17' W	69° 08' N
J6	136° 26' W	69° 04' N
J7	136° 40' W	68° 59' N
J8	136° 53' W	68° 54' N
K1	135° 51' W	69° 29' N
K2	136° 02' W	69° 24' N
K3	136° 13' W	69° 19' N
K4	136° 26' W	69° 13' N
K5	136° 42' W	69° 08' N
K6	136° 53' W	69° 03' N
K7	137° 08' W	68° 57' N
α 1	136° 08' W	69° 03' N
α 2	136° 18' W	68° 58' N
α 3	136° 28' W	68° 54' N
L	134° 29' W	69° 28' N
M	134° 39' W	69° 31' N
N	135° 08' W	69° 28' N
O	135° 20' W	69° 25' N
P	135° 32' W	69° 21' N
Q	135° 38' W	69° 18' N
R	135° 52' W	69° 14' N
S	135° 16' W	69° 21' N
T	135° 18' W	69° 18' N
U	135° 07' W	69° 13' N
V	135° 00' W	69° 09' N
W	135° 56' W	69° 04' N
X	135° 59' W	68° 53' N

Table I Salinity Stations, 1971 and 1972 (continued)

Y	135° 25' W	68° 45' N
Z	134° 55' W	68° 37' N
Reindeer 1	135° 30' W	68° 54' N
Reindeer 2	135° 12' W	68° 55' N
Reindeer 3	134° 54' W	68° 53' N
West 1	136° 10' W	68° 52' N
West 2	136° 02' W	68° 48' N
West 3	135° 42' W	68° 38' N
West 4	135° 26' W	68° 25' N
Middle 1	134° 51' W	68° 58' N
Middle 2	134° 39' W	68° 53' N
Middle 3	134° 32' W	68° 46' N
East 1	133° 56' W	69° 19' N
East 2	134° 06' W	69° 17' N
East 3	134° 13' W	69° 15' N
East 4	134° 18' W	69° 09' N
East 5	134° 38' W	69° 02' N
East 6	134° 24' W	68° 46' N
Denis Lake	134° 34' W	69° 20' N
"Y" Lake	134° 13' W	69° 13' N
Lake #11	133° 30' W	69° 16' N
Lake #12	132° 51' W	69° 19' N
Lake A	132° 57' W	69° 33.5' N
Lake B	132° 54' W	69° 38.2' N
Lake C	132° 41' W	69° 33' N
Lake D	134° 24' W	69° 39' N
Lake E	134° 25' W	69° 37' N
Lake F	134° 25' W	69° 35.7' N
Lake G	131° 23' W	69° 55' N
Lake H	131° 04' W	69° 47' N
Lake J	132° 27' W	69° 38.5' N
Lake K	132° 16' W	69° 38.5' N
Lake L	132° 07' W	69° 32' N
β	131° 58' W	69° 46' N
γ	131° 26' W	69° 58' N
Liverpool Bay	130° 45' W	69° 39' N

Table II   Temperature and Salinity Observations, 1971

Station (Date)	Depth (m)	Temperature (°C)	Salinity (0/00)
A1 (1-9-71)	0	7.1	0.3
	1	7.1	0.3
	2	7.2	0.3
A2 (1-9-71)	0	6.7	0.3
	1	6.7	0.2
	2	6.7	0.2
	3	6.8	0.3
A3 (1-9-71)	0	7.3	0.25
B1 (1-9-71)	0	6.1	5.5
	1	6.1	6.1
	2	5.4	12.0
	3	5.0	13.3
	4	5.5	13.6
B2 (9-9-71)	0	6.4	0.5
	1	6.4	0.4
	2	6.4	0.45
B3 (9-9-71)	0	6.6	0.90
	1	6.2	1.10
	2	6.3	1.30
B4 (1-9-71)	0	4.7	0.45
C1 (1-9-71)	0	5.8	13.30
	1	5.8	13.30
	2	5.9	13.80
C2 (9-9-71)	0	5.4	1.20
	1	5.3	1.20
	2	4.9	10.80
	3	4.4	13.00
	4	4.4	13.00
C3 (9-9-71)	0	4.7	2.80
	1	4.7	2.90
	2	4.2	7.10
	3	3.9	9.30
C4 (9-9-71)	0	3.8	8.5
	1	3.8	8.5
	2	3.5	8.6
	3	3.7	10.0
C5 (1-9-71)	0	5.4	2.7
D1 (9-9-71)	0	4.7	9.0
	1	4.2	10.6
	2	4.3	13.8
	3	4.3	15.0
	4	4.3	16.0

D2	0	5.0	4.9
(9-9-71)	1	4.4	5.3
	2	4.4	12.2
	3	4.1	13.9
	4	4.2	14.8
	5	4.2	14.9
D3	0	4.2	5.4
(9-9-71)	1	3.6	7.4
	2	4.0	13.0
	3	4.0	16.9
	4	4.0	17.8
	5	4.2	19.0
D4	0	3.6	12.8
(9-9-71)	1	3.3	14.7
	2	3.8	18.2
	3	3.9	18.5
	4	3.9	19.1
	5	4.1	19.1
D5	0	4.0	13.0
(9-9-71)	1	3.7	14.3
	2	3.7	15.1
	3	3.7	17.5
	4	3.5	17.5
D6	0	4.85	7.8
(1-9-71)	1	5.1	7.5
E1	0	4.3	16.5
(9-9-71)	1	4.3	16.9
	2	4.4	16.8
	3	4.4	18.2
	4	4.7	19.1
	5	4.7	19.6
	6	4.4	21.1
E2	0	4.4	16.6
(9-9-71)	1	4.4	16.7
	2	4.35	16.8
	3	4.60	17.9
	4	4.60	18.3
	5	4.50	18.3
	6	4.70	18.7
	7	4.70	19.3
E3	0	4.90	14.3
(9-9-71)	1	4.00	15.0
	2	4.10	16.7
	3	4.10	18.0
	4	4.10	17.8
	5	4.50	18.2
E4	0	4.7	12.2
(9-9-71)	1	4.0	12.1
	2	4.0	12.3
	3	4.1	18.9
	4	3.9	19.1

	5	4.2	20.5
	6	4.1	21.7
	7	4.3	22.0
	8	4.3	22.0
	9	4.1	22.0
E5	0	4.5	17.2
(9-9-71)	1	4.1	20.2
	2	4.9	20.6
	3	3.9	20.9
	4	4.2	21.4
	5	4.2	21.2
	6	4.2	21.5
	7	4.3	21.7
	8	4.3	22.2
E6	0	4.4	17.1
(9-9-71)	1	3.7	17.9
	2	3.8	19.7
	3	3.8	19.8
F1	0	3.7	1.6
(1-9-71)			
F2	0	4.5	1.7
(10-9-71)			
F4	0	4.6	0.4
(10-9-71)			
G1	0	4.8	4.5
(11-9-71)	1	4.2	11.5
G2	0	5.7	1.55
(11-9-71)	1	3.8	4.1
	2	3.8	14.3
G3	0	6.5	2.3
(11-9-71)	1	5.9	2.9
	2	3.8	12.8
G4	0	6.9	1.25
(11-9-71)	1	6.8	2.30
G5	0	8.5	0.55
(10-9-71)	1	8.5	0.60
G6	0	5.0	1.30
(10-9-71)			
H1	0	4.7	16.0
(9-9-71)	1	3.9	17.9
	2	3.9	19.7
	3	3.9	21.7
	4	3.9	22.6
	5	4.2	22.8
H2	0	4.2	7.2
(9-9-71)	1	3.4	9.9
	2	4.3	15.0
	3	3.5	22.1
H3	0	4.1	3.2
(9-9-71)	1	2.8	5.9
	2	2.7	12.3
	3	3.2	22.9

H4	0	4.2	5.0
(9-9-71)	1	3.4	22.6
	2	3.4	22.8
	3	3.5	22.7
H5	0	5.9	0.8
(9-9-71)	1	4.2	6.8
	2	3.0	20.1
H6	0	5.6	1.6
(9-9-71)	1	5.6	1.8
	2	3.1	20.4
	3	3.3	20.8
J1	0	9.0	0.30
(10-9-71)	1	9.0	0.25
J3	0	5.7	0.30
(10-9-71)	1	5.7	0.25
J7	0	4.1	0.25
(9-9-71)	1	4.2	0.25
	2	4.2	0.20
J8	0	4.0	3.10
(11-9-71)			
K1	0	6.4	0.70
(9-9-71)	1	6.5	0.75
	2	6.0	0.75
K3	0	5.3	0.70
(9-9-71)	1	4.0	7.8
K5	0	3.3	3.4
(9-9-71)	1	3.6	3.4
K7	0	3.1	2.2
(9-9-71)			
α2	0	7.4	0.35
(9-9-71)	1	7.6	0.35
α3	0	5.1	0.30
(2-9-71)	1	4.8	0.30
L	0	6.0	7.0
(1-9-71)	1	6.2	7.0
	2	6.0	7.0
	3	6.0	7.1
	4	6.1	7.1
	5	6.2	7.1
	6	6.2	7.1
	7	6.3	7.1
	8	6.25	7.1
	9	6.7	7.7
	13	6.8	17.1
M	0	5.0	6.8
(1-9-71)	1	5.0	6.6
N	0	5.7	0.4
(1-9-71)	1	5.6	0.3
O	0	10.0	0.3
(1-9-71)	1	9.8	0.3
	2	9.8	0.2
P	0	6.3	0.3
(1-9-71)			

Q (1-9-71)	0	9.7	0.25
	1	9.7	0.20
	2	9.7	0.20
R (1-9-71)	0	7.25	0.20
	1	7.20	0.20
S (2-9-71)	0	9.8	0.35
	1	9.8	0.30
	2	9.8	0.30
	3	9.8	0.30
	4	9.7	0.30
	5	9.7	0.30
	6	9.8	0.30
	7	9.8	0.30
	8	9.7	0.25
T (2-9-71)	0	9.6	0.30
	1	9.6	0.30
	2	9.6	0.25
	3	9.6	0.30
	4	9.7	0.30
	5	9.8	0.30
	6	9.8	0.25
U (2-9-71)	0	9.9	0.25
	1	9.9	0.30
	2	10.0	0.30
	3	10.0	0.30
	4	9.9	0.30
	5	9.9	0.25
	6	9.9	0.25
	7	9.9	0.30
	8	9.9	0.30
	9	9.9	0.30
	10	9.9	0.30
V (2-9-71)	0	9.8	0.3
	1	9.8	0.3
	2	9.9	0.3
	3	9.9	0.3
	4	9.9	0.3
	5	9.7	0.3
	6	9.8	0.3
	7	9.8	0.3
	8	9.8	0.3
	9	9.9	0.3
	10	9.9	0.3
	11	9.8	0.3
	12	9.8	0.25
W (1-9-71)	0	9.9	0.3
	1	9.85	0.2
	2	10.1	0.2
	3	10.0	0.25
	4	10.0	0.3
	12	10.0	0.3

X (2-9-71)	0	5.6	0.3
	1	5.7	0.3
	2	5.7	0.25
	3	5.5	0.25
Y (2-9-71)	0	8.0	0.30
Z (2-9-71)	0	8.3	0.30
	1	8.4	0.35
Reindeer 1 (2-9-71)	0	7.7	0.35
	1	7.7	0.30
	2	7.7	0.30
Reindeer 2 (2-9-71)	0	9.5	0.25
	1	9.5	0.25
	2	9.8	0.25
	3	9.8	0.30
	4	9.8	0.30
	5	9.8	0.30
	6	9.9	0.30
	7	9.9	0.3
	8	9.8	0.3
	9	9.7	0.3
	10	9.8	0.3
	11	9.8	0.25
	12	9.8	0.30
	13	9.8	0.30
Reindeer 3 (2-9-71)	0	10.1	0.30
	1	10.1	0.20
	2	9.8	0.25
	3	9.8	0.20
	4	10.2	0.20
	5	10.2	0.25
	6	9.8	0.25
	7	9.8	0.25
	8	10.0	0.25
	9	9.7	0.25
	10	9.8	0.25
	11	9.7	0.25
	12	9.9	0.30
	13	9.9	0.25
West 1 (2-9-71)	0	6.5	0.30
West 2 (2-9-71)	0	7.0	0.3
	1	7.0	0.3
	2	7.0	0.3
West 3 (2-9-71)	0	7.5	0.3
	1	7.5	0.3
West 4 (2-9-71)	0	7.8	0.3
	1	7.8	0.3
	2	7.9	0.3

Middle 1 (11-9-71)	0	10.2	0.3
	1	10.2	0.3
	2	10.1	0.25
	3	10.1	0.3
	4	10.3	0.3
	5	10.2	0.25
	6	10.1	0.25
	7	10.1	0.30
Middle 2 (11-9-71)	0	9.3	0.30
	1	5.4	0.45
	2	9.4	0.25
	3	9.4	0.35
	4	9.6	0.35
Middle 3 (11-9-71)	0	9.4	0.30
	1	9.4	0.30
East 1 (10-9-71)	0	8.5	0.25
	1	8.5	0.25
	2	8.5	0.25
	3	8.3	0.25
	4	8.25	0.30
	5	8.4	0.30
East 2 (10-9-71)	0	8.6	0.30
	1	8.6	0.25
	2	8.4	0.25
	3	8.4	0.30
	4	8.4	0.40
East 3 (10-9-71)	0	8.4	0.20
	1	8.4	0.20
	2	8.4	0.35
	3	8.4	0.25
	4	8.4	0.15
	5	8.4	0.20
	6	8.4	0.20
East 4 (10-9-71)	0	8.3	0.25
	1	8.4	0.30
	2	8.4	0.45
	3	8.4	0.25
	4	8.4	0.25
East 5 (10-9-71)	0	7.1	0.30
East 6 (10-9-71)	0	7.8	0.30
	1	7.8	0.25
	2	7.9	0.30
Denis Lake (10-9-71)	0	4.7	0.3
	1	4.7	0.25
	2	4.7	0.25
	3	4.6	0.25
	4	4.6	0.20
	5	4.6	0.25
	6	4.5	0.20
	7	4.7	0.2
	8	4.7	0.2

(cont'd.)

Denis Lake (cont'd.)

	9	4.7	0.2
	10	4.7	0.3
	11	4.6	0.2
	12	4.6	0.2
'Y' Lake	0	5.4	0.2
(10-9-71)	1	5.4	0.25
	2	5.4	0.25
	3	5.4	0.25
	4	5.4	0.25
	5	5.4	0.25
	6	5.4	0.25
	7	5.3	0.25
	8	5.2	0.3
	9	5.2	0.3
	10	5.3	0.3
	11	5.2	0.3
	12	5.2	0.3
	13	5.3	0.3
Lake 11	0	4.25	0.2
(10-9-71)	1	4.2	0.15
	2	4.2	0.15
Lake 12	0	4.3	0.1
(10-9-71)	1	4.3	0.15
	2	4.3	0.15
	3	4.4	0.15
	4	4.4	0.15
	5	4.5	0.1
Lake A	0	3.5	0.3
(10-9-71)	1	3.5	0.4
	2	3.5	0.3
Lake B	0	2.5	7.8
(10-9-71)	1	2.4	7.8
Lake C	0	3.7	0.25
(10-9-71)	1	3.6	0.30
	2	3.5	0.30
Lake D	0	3.65	0.3
(10-9-71)	1	3.7	0.3
	2	3.7	0.2
	3	3.7	0.2
Lake E	0	3.6	0.35
(10-9-71)	1	3.4	0.35
	2	3.5	0.4
	3	3.2	0.4
Lake F	0	4.0	0.55
(10-9-71)	1	4.0	0.6
	2	4.0	0.6
	3	4.0	0.65
	4	3.9	0.65
	5	3.85	0.60
	6	3.9	0.60

Lake G	0	3.3	0.3
(15-9-71)	1	3.3	0.35
Lake H	0	3.9	0.30
(15-9-71)	1	3.8	0.3
	2	3.8	0.25
	3	3.8	0.3
	4	3.8	0.3
	5	3.8	0.3
	6	3.8	0.3
Lake J	0	3.9	15.4
(15-9-71)	1	3.9	15.4
	2	4.1	15.4
	3	4.0	15.4
	4	4.0	15.5
Lake K	0	4.0	0.3
(15-9-71)	1	3.9	0.2
Lake L	0	4.0	0.2
(15-9-71)	1	4.0	0.2
	2	4.0	0.2
	3	4.0	0.2
β	0	4.1	21.4
(15-9-71)	1	4.0	21.5
γ	0	3.8	22.4
(15-9-71)	1	3.9	22.4
	2	3.9	22.4
	3	3.7	22.4
	4	3.7	22.2
	5	3.7	22.2
	6	3.8	22.1
Liverpool Bay	0	4.5	19.5
(15-9-71)	1	4.5	19.5
	2	4.5	19.5

Table III Temperature and Salinity Observations, July 14, 1972

Station	Depth (m)	Temperature (°C)	Salinity (0/00)
C1	0	2.83	0.87
	1	2.83	0.84
	2	2.75	0.87
	3	2.79	0.87
	4	2.71	0.91
	5	2.65	0.93
C2	0	10.67	0.64
	1	10.66	0.64
	2	10.56	0.68
	3	10.56	0.68
	4	10.56	0.66
C3	0	15.0	0.28
	1	15.0	0.30
	2	14.9	0.25
	3	14.9	0.28
C4	0	16.29	0.28
	1	16.43	0.33
	2	16.43	0.36
E1	0	2.80	1.56
	1	2.78	0.96
	2	2.80	1.10
	3	3.76	0.97
	4	1.68	3.47
	5	1.37	3.68
E2	0	0.60	0.94
	1	0.55	0.93
	2	0.20	1.53
	3	0.17	1.48
	4	0.00	1.64
	5	0.00	1.67
	6	0.00	2.92
	7	<0	2.95
	8	<0	3.10
	9	<0	3.10
E3	0	2.83	0.94
	1	2.83	0.93
	2	2.90	0.95
	3	2.90	0.95
	4	2.37	0.95
	5	2.00	1.00
	6	3.14	26.10
	7	-	26.55
E4	0	8.29	0.58
	1	8.20	0.63
	2	8.20	0.57
	3	8.15	0.63
	4	7.42	0.55
	5	7.15	0.88
	6	6.27	0.98

E5	0	0.80	1.02
	1	0.83	1.00
	2	0.93	2.21
	3	0.00	2.32
E6	0	9.60	0.97
	1	8.12	0.88
	2	7.39	1.00
	3	5.49	1.53
	4	5.52	1.58
F1	0	12.08	0.61
	1	12.12	0.66
F2	0	13.34	0.32
	1	13.36	0.33
F3	0	17.68	1.58
	1	17.76	1.58
F4	0	17.74	0.36
	1	17.84	0.34
G1	0	5.78	0.31
	1	5.84	0.60
	2	5.76	0.70
G2	0	5.62	0.52
	1	5.60	0.52
	2	5.60	0.52
G4	0	14.12	0.35
	1	14.12	0.35
G5	0	16.81	0.39
	1	16.81	0.39
G6	0	16.86	0.72
	1	16.88	0.74
H1	0	2.37	0.85
	1	2.27	0.97
	2	1.83	0.88
	3	2.01	1.01
	4	2.01	1.06
H2	0	3.10	1.10
	1	3.02	1.05
	2	2.88	1.25
H4	0	5.97	1.02
	1	5.95	1.08
	2	5.64	1.18
	3	5.64	1.10
H5	0	15.26	0.70
	1	15.26	0.60
	2	14.86	0.92
	3	14.12	0.99
H6	0	16.79	0.29
	1	16.86	0.34
	2	16.87	0.35
	3	16.87	0.37
J7	0	15.80	0.43
	1	15.74	0.47
K1	0	16.19	0.31
	1	16.10	0.45
	2	16.10	0.45

K2	0	16.25	0.80
	1	16.25	0.57
	2	16.23	0.86
	3	16.23	0.35
K3	0	16.64	0.33
	1	16.56	0.35
K4	0	15.48	0.32
	1	15.48	0.60
	2	15.48	0.30
K5	0	15.41	0.36
	1	15.40	0.38
K6	0	15.90	0.24
	1	15.84	0.37
	2	15.78	0.36
K7	0	15.79	0.46
	1	15.90	0.59
	2	15.78	0.66
K8	0	14.92	1.38

APPENDIX III

The percentage occurrence of zoobenthic taxa, and mean number of individuals organisms per sample, at selected stations in Mackenzie and Porcupine watersheds in 1971.

Table I. Mackenzie mainstream - Surber samples, 1971.

Station	Date	Nematoda	Hirudinea	Oligochaeta	Gastropoda	Pelecypoda	Isopoda	Amphipoda	Odonata	Plecoptera	Ephemeroptera	Hemiptera	Trichoptera	Coleoptera	Misc. Diptera	Tipulidae	Simuliidae	Chaoboridae	Chironomidae	Ceratopogonidae	Empididae	Acarina	Polychaeta	Cumacea	Tabanidae	Mean Number/m^2
RG	11/08/71	1.6		8.0	6.4	1.6		1.6			15.9			3.2					49.2			12.7				226.0
PS II	10/08/71	1.8		2.9	4.1					3.5							1.8		82.2	2.9		1.2				624.1
CD	10/08/71							2.7			2.7		2.7						89.2			2.7				132.7
TT	08/08/71	0.2		6.2	0.7					17.3	9.4		3.7		1.2	2.9	2.7		52.1			4.0				2155.6
BB	07/08/71			0.5				90.2		7.6						1.4	0.2					0.2				2851.4
CB	30/08/71			4.1						50.0									45.3		0.7					530.5
NA	12/08/71			17.1	4.9									2.5		2.5			68.3	4.9						147.1
PE	10/09/71	21.7		37.9						5.4									32.5		2.7					132.3
MT	20/09/71									33.3									66.7							10.7
RP	09/09/71			46.9						28.2			3.2						21.9							115.1
LN	09/09/71			30.0						40.0					10.0				20.0							35.5
TE	10/09/71			70.4						13.0	5.6				1.9	3.7			3.7		1.9					193.7
OC	06/09/71			68.8						6.3	18.8								6.3							115.7
OC	18/09/71			68.2						2.3	6.8								18.2	2.3					2.3	158.2
DC	06/09/71			28.6															71.4							24.7
BK	04/09/71			72.9	2.1								2.1		2.1				20.8							172.2
BK	17/09/71	1.2		81.4	2.3	4.7		3.5					2.3		1.2				3.5							462.7
RC	15/09/71			7.1							64.3								28.6							50.5
LO	08/09/71									68.5									31.6							32.3
CY	01/09/71			63.7						9.1	9.1								18.2							39.5
CT	31/08/71									40.0					20.0				40.0							26.9
WC	01/09/71			96.9							1.6						1.6									226.0
VC	12/09/71			86.0						10.0									4.0							179.4
SL	01/09/71									33.3		33.3							33.3							10.7
SL	12/09/71			66.7									33.3													10.7
BF	02/09/71	4.3		29.8						12.8		2.1	10.6			2.1	2.1		21.3		10.6	2.1			2.1	168.9
BF	13/09/71			4.0						67.1	1.3	1.3	15.8			2.6			7.9							272.2
LB	12/09/71									10.0	40.0		20.0				10.0		20.0							35.5

Table I. Mackenzie mainstem - Surber samples, 1971. (continued)

Station		Date	Nematoda	Hirudinea	Oligochaeta	Gastropoda	Pelecypoda	Isopoda	Amphipoda	Odonata	Plecoptera	Ephemeroptera	Hemiptera	Trichoptera	Coleoptera	Misc. Diptera	Tipulidae	Simuliidae	Chaoboridae	Chironomidae	Ceratopogonidae	Empididae	Acarina	Polychaeta	Cumacea	Tabanidae	Mean Number/m^2
TR		16/09/71	1.2		3.5	2.3					3.7	13.7		0.7	0.4					72.6	0.7	0.7	0.4				4182.4
TR		16/09/71	2.5		4.1	5.8					0.2	3.6	2.8	1.3						70.8	5.3	0.6					1904.5
TR	slow	06/08/71			18.3	4.4						3.4	1.5	1.5						70.2	1.0						1119.0
TR	slow	18/08/71	4.2		31.5	5.1	0.4			1.3		2.3	6.4	2.9	0.4					42.9	1.6	1.0	0.7				1129.8
TR	fast	18/08/71	3.1		3.3	0.7					1.2	5.2		0.3	0.5			0.3		83.8		1.2	0.7				1524.7
TR	slow	31/08/71	1.6		10.1	13.2				0.8		4.7	0.8	3.1	3.1					55.1	7.0	0.8					462.7
TR	fast	31/08/71	2.3		6.0	6.3					3.3	7.8		0.9	0.5		4.6			64.7	0.5	2.4	1.2				2417.8
MR	fast	15/09/71			2.9	0.4					23.4	41.3		3.6			0.4	1.5		27.2			1.2				20311.7
MR	slow	17/08/71	0.4		8.1	5.0						24.0		3.8	1.3					51.3	3.5	2.2	0.7				1154.5
MR	fast	17/08/71			15.8	1.3	23.1		0.6		4.3	22.5		4.3				1.9		24.3	1.3	0.6	0.6				591.8
MR	fast	23/08/71	1.2		14.5	3.1					16.9	25.9		2.4	0.6	1.2				33.2		0.6	0.6				893.1
MR	slow	23/08/71	0.9		4.0	0.2				0.2	3.0	28.4			0.2		0.2			59.5	2.5	0.5	0.7				1718.4
MR	slow	30/08/71	0.7		3.2	0.7					28.4	29.8		3.5	0.7			1.1		28.7	0.4	0.4	2.8				1025.4
HR	slow	09/08/71	0.5		21.0	2.6						3.9		1.3	0.5		12.4	0.5		54.7		0.5	2.6				1258.9
HR	slow	16/08/71			16.3	2.5			7.5		4.4	9.4		1.9	28.4		2.1	0.5		25.5	0.9		2.3				1721.6
HR	slow	23/08/71			22.9	14.3	0.1				0.6	5.0		2.8	2.3		5.6	0.1		42.1	0.8	0.7	3.2				3278.6
HR	slow	30/08/71	0.2		54.4	6.9						2.7		0.1	0.4	0.1	4.0			30.0			1.2				59209.1
HR	fast	16/08/71	0.2		27.3	0.8					1.8	0.1		9.1	3.0	0.1	2.3			39.2		0.3	14.8				6377.5
HR	fast	23/08/71	0.4		10.4	7.3	0.5			0.1	2.0			17.7	7.0		6.6			13.0			34.2				3432.4
RR	slow	08/09/71	0.2		1.1	7.2				0.5	0.2	22.6		1.8	2.1					62.9	0.9	0.1	0.5				4605.3
RR	slow	25/08/71	0.2		0.1	2.3	0.8			0.5		15.4	0.1	1.3	0.8					77.2	1.1		0.1				6886.4
JM	slow	08/09/71	0.2		0.6	0.3	2.4		2.8	0.2		8.4	0.9	1.2	0.2					80.6	1.0		1.3				3631.5
JM	fast	08/09/71			1.9	3.7						43.5		13.9						37.0							387.4
JM	slow	25/08/71	0.4	0.1	1.4	2.1	1.8			0.9		20.3	0.3	2.6						66.8	1.8		1.3				3948.9
JM	fast	25/08/71				1.8				0.3	0.9	34.5	0.5	3.3				0.5		56.0	0.7		2.0				2480.2

Table II. Mackenzie mainstream - artificial substrates, 1971.

Station		Date	Nematoda	Hirudinea	Oligochaeta	Gastropoda	Pelecypoda	Isopoda	Amphipoda	Odonata	Plecoptera	Ephemeroptera	Hemiptera	Trichoptera	Coleoptera	Misc. Diptera	Tipulidae	Simuliidae	Chaoboridae	Chironomidae	Ceratopogonidae	Empididae	Acarina	Polychaeta	Cumacea	Tabanidae	Mean Number/ Substrate
PS[II]	pool	06/09/71	10.3		31.1	12.8					7.1									36.3	2.1						146.0
PS[I]	riffle	06/09/71			3.7						62.5			4.5			0.8			28.7							45.3
TT	riffle	05/09/71									50.6	6.6		8.6	0.3		0.8	2.9		30.2							216.7
TT	pool	05/09/71	0.4		1.1						34.2			13.2			3.8	0.4		47.0							88.7
BB	riffle	04/09/71							14.8		70.5						4.9	1.6		8.2							20.3
BB	pool	09/09/71							48.5		27.3			15.2						9.1							11.0
PL	pool	12/09/71	1.1		2.4						22.9	13.3	10.4	0.3	0.3	0.3	0.3			43.7	1.0						105.3
LN		19/09/71			3.0						82.7			0.6						13.7							56.0
TE		20/09/71									2.0						1.3	0.7		95.4		0.7					50.7
GC		20/09/71	1.1		0.6						56.6	0.6		1.1				18.3		21.7							87.5
OC		18/09/71			2.6						5.1	48.7		2.6				33.3		7.7							13.0
OC		18/09/71									9.3	35.2						27.8		27.8							18.0
BK		23/09/71			3.2						6.4				1.1			44.7		43.6			2.1				31.3
LO		23/09/71	0.1		1.1						62.4			0.7		0.1		7.1		27.1		0.1	1.1				244.7
FA		22/09/71				0.4					86.9	1.8	0.7	2.0			0.2	1.3		6.7							150.3
CT		22/09/71			11.1	12.4					25.9			1.2				1.2		44.4			3.7				27.0
HC		22/09/71			2.3						18.2					4.6				72.7	2.3						14.7
PB		22/09/71									32.7	0.4		2.8		-	0.4	19.4		44.4							82.7
BD		11/09/71	0.8	0.1	77.7	3.7	0.7			0.5	0.4	0.1	0.5				0.1			14.7			0.7				381.5
BD		11/09/71	0.1		46.6	6.3	0.2				4.4	8.8	2.3	2.2	0.2	0.2	0.5			9.8	17.9		0.2				220.5
BF	riffle	22/09/71	1.5		2.5						25.3			6.9			1.5	3.0		56.4			3.0				67.3
BF	pool	22/09/71	3.8		11.4	3.8				1.0	5.7		1.0	2.9						64.8	1.0		4.8				35.0
SE	riffle	10/09/71	1.1		0.2						9.4	0.7	2.0	9.2			0.4	0.2		75.4		1.5					153.0
SE	riffle	10/09/71	0.8		1.1						8.9	2.4		15.7		6.4	0.3	1.4		60.3	0.2	2.0					213.0
BT	riffle	10/09/71			0.2						39.7	2.5		2.7				25.0		28.7			1.2				911.7
BT	pool	10/09/71	0.2		13.9	0.3					2.5	13.1	6.1	2.7		0.6				58.6		0.1	1.8				293.3
WL	pool	10/09/71	0.6	0.1	29.4	0.8	0.1			0.1	0.3	3.4	1.7		0.2			0.3		62.3	0.5		0.1				294.7
WL	pool	10/09/71	0.9		27.7	1.6	0.1			0.1	0.2	7.7	1.1	0.1	0.1					59.7	0.6						293.3

Table II. Mackenzie mainstem - artificial substrates, 1971. (continued)

Station		Date	Nematoda	Hirudinea	Oligochaeta	Gastropoda	Pelecypoda	Isopoda	Amphipoda	Odonata	Plecoptera	Ephemeroptera	Hemiptera	Trichoptera	Coleoptera	Misc. Diptera	Tipulidae	Simuliidae	Chaoboridae	Chironomidae	Ceratopogonidae	Empididae	Acarina	Polychaeta	Cumacea	Tabanidae	Mean Number/ Substrate
TR		23/09/71	0.1			1.0					24.8	4.9		4.5			0.1	1.6		62.8		0.2					1400.3
MR		18/09/71	1.1		4.0	0.9					0.1	65.4	0.3	0.3	0.6	0.1				27.0	0.3	0.1	0.1				536.0
HR	riffle	20/09/71	0.1		5.2	18.4				0.8	1.2	33.0	0.1	5.1	0.3	0.3	0.1	1.2		34.1							248.3
HR	pool	20/09/71			1.0	29.7				0.8		19.7		18.7	0.3			0.2		29.3	0.2		0.2				203.3
MA		23/09/71				0.2					22.2	4.7		12.5				43.1		17.6							302.0
MA		23/09/71			0.6						27.5	5.5		9.6				38.7		18.3							340.0
JM		21/09/71			1.0	0.2					2.5	1.3		0.9			0.1	31.6		61.0	0.1		1.3				12631.3
LR		22/09/71									5.3	2.9		1.2				89.4		1.2							146.8
LR		22/09/71									51.8	18.4		13.5	0.7			10.6		5.0							47.0
LR		22/09/71			1.0						24.2	21.2		10.1				39.4		4.0							33.0
RR		22/09/71			0.2	7.8					2.7	12.8	0.1	19.9	0.6		2.9	0.3		44.8			7.8				817.3
PT	riffle	09/09/71									2.0	64.5	0.5	2.7	0.1			0.9		29.0	0.2		0.1				295.3
PT	pool	09/09/71	0.2		3.0	0.1	0.1			0.1	0.5	57.7	3.8	0.1						30.7	3.6						412.0

Table III Mackenzie Delta - dredge samples, 1971.

Station		Date	Nematoda	Hirudinea	Oligochaeta	Gastropoda	Pelecypoda	Isopoda	Amphipoda	Odonata	Plecoptera	Ephemeroptera	Hemiptera	Trichoptera	Coleoptera	Misc. Diptera	Tipulidae	Simuliidae	Chaoboridae	Chironomidae	Ceratopogonidae	Empididae	Acarina	Polychaeta	Cumacea	Tabanidae	Mean Number/m^2
BS13		27/08/71	0.5			0.3	9.6		0.3															89.4			5390
BS14		27/08/71							3.9															96.1			1064
BS15		27/08/71				78.6		4.8	16.7																		588
BS18		09/09/71					60																	40			420
BS19		09/09/71				2.6	20.1																	76.3	1.0		2716
BS20		09/09/71					28.8																	71.2			4284
BS22		09/09/71							50															50			28
BS23		09/09/71							9.1															90.9			154
BS24		11/09/71							100																		28
BS25		11/09/71							50															50			56
KU4		26/08/71	5.6						2.8															77.8	13.9		504
KU4		11/12/71							2.9											2.9				94.3			490

Table III. Mackenzie Delta - dredge samples, 1971.

Station	Date	Nematoda	Hirudinea	Oligochaeta	Gastropoda	Pelecypoda	Isopoda	Amphipoda	Odonata	Plecoptera	Ephemeroptera	Hemiptera	Trichoptera	Coleoptera	Misc. Diptera	Tipulidae	Simuliidae	Chaoboridae	Chironomidae	Ceratopogonidae	Empididae	Acarina	Polychaeta	Cumacea	Tabanidae	Mean Number/m²
KU5	26/08/71					6.3																	93.8			224
KU7	26/08/71	1.1				2.1		3.2											1.1				71.3	21.3		1316
KU8	26/08/71																						100			14
KU17	09/09/71							100																		14
L1	17/09/71			4.2	4.2	91.7																				336
L1	16/12/71			18.2	4.5	36.4	18.2												22.7							308
L2	17/09/71	1.6	1.2	30.1	14.5	34.5		1.2					0.2						13.5	1.4		1.9				6006
L3	17/09/71			25.0	56.3	9.4		6.3												3.1						448
L4	17/09/71			1.7	74.7	22.6							0.3						0.7							4088
L5	17/09/71		0.2	9.3	68.3	15.4		0.3				0.1	0.5						5.5	0.2		0.2				17976
L6	17/09/71	1.6	0.8	3.2	12.8	73.6		0.8											7.2							1750
L7	17/09/71	0.3	0.1	5.6	59.5	31.2							0.4						2.3	0.3		0.2				38906
L11	27/08/71			5.1	52.9	32.5													9.6							2198
L12	27/08/71	50		30.2	9.4	7.5													35.8							742
L12	13/12/71	6.7		66.7															26.7							870
"Y" Lake	26/08/71	0.3		13.4	30.4	10.4		0.7					0.3						44.5							4186
Denis Lake	26/08/71			17.2	2.6	3.7		3.3											73.3							3822
EC2	24/08/71			3.3	7.4	52.1		37.2																		1694
EC1-1	23/08/71			7.1				92.9																		196
EC1-2	23/08/71			19.0	9.5			61.9												9.5						294
EC1-3	23/08/71				100																					116
EC1-1	17/12/71	3.3						13.3											73.3	10.0						420
EC1-2	17/12/71							7.4											79.6	13.0						756
EC1-3	17/12/71	3.5											2.3						88.4	5.8						1204

Table III. Mackenzie Delta - dredge samples, 1971. (continued)

Station	Date	Nematoda	Hirudinea	Oligochaeta	Gastropoda	Pelecypoda	Isopoda	Amphipoda	Odonata	Plecoptera	Ephemeroptera	Hemiptera	Trichoptera	Coleoptera	Misc. Diptera	Tipulidae	Simuliidae	Chaoboridae	Chironomidae	Ceratopogonidae	Empididae	Acarina	Polychaeta	Cumacea	Tabanidae	Mean Number/m^2
EC3-1	24/08/71			7.7	61.5			50			7.7		7.7						15.4							238
EC3-2	24/08/71																			50						36
EC3-3	24/08/71																		100							55
EC3-1	03/12/71				4.3					4.3			4.3						73.9		13.0					322
EC3-3	03/12/71																1.6		95.2	3.2						882
EC4-1	03/09/71	7.1		35.7															42.9	14.3						256
EC4-2	03/09/71			11.8	5.9														70.6	11.8						265
EC4-3	03/09/71																		100							55
EC4-1	05/12/71																		100							112
EC4-3	05/12/71			6.7		6.7													80	6.7						210
EC6-1	22/09/71			20	20	10		30											20							140
EC6-2	22/09/71												100													32
EC6-3	22/09/71				16.7			33.3											50							84
EC7-1	11/09/71			66.7															33.3							47
EC7-2	11/09/71			80		20																				78
EC7-3	11/09/71			100																						62
EC8-1	11/09/71			92.9															7.1							437
EC8-2	11/09/71				71.4	28.6																				109
EC8-3	11/09/71			100																						1841
EC9-1	13/09/71				85.7	10.7													3.6							392
EC9-2	13/09/71				88.6														11.4							490
EC9-3	13/09/71																		100							28
WC1-1	05/09/71																		100							32
WC1-2	05/09/71							33.3											66.7							47
WC1-3	05/09/71			100																						218
WC1-3	16/12/71							12.5											50	37.5						112
WC2-2	05/09/71			77.8															22.2							140
WC2-3	05/09/71			85.7															14.3							109

Table III. Mackenzie Delta - dredge samples, 1971. (continued)

Station	Date	Nematoda	Hirudinea	Oligochaeta	Gastropoda	Pelecypoda	Isopoda	Amphipoda	Odonata	Plecoptera	Ephemeroptera	Hemiptera	Trichoptera	Coleoptera	Misc. Diptera	Tipulidae	Simuliidae	Chaoboridae	Chironomidae	Ceratopogonidae	Empididae	Acarina	Polychaeta	Cumacea	Tabanidae	Mean Number/m^2
MC1-1	05/09/71			87.5															12.5							125
MC1-3	05/09/71		90.9		4.5									4.5												343
MC3-1	13/09/71																			100						14
MC3-2	13/09/71				40	40													20							70
MC3-3	13/09/71		83.3																16.7							84
MC4-1	22/09/71				33.3			66.7																		42
MC4-2	22/09/71																		100							14
MC5-2	03/09/71																		33.3	66.7						42
NC1-1	05/09/71		80					20																		78
NC1-2	05/09/71				100																					62
NC2-1	22/09/71			18.2															81.8							154
NC2-2	22/09/71				55.6	44.4																				126
NC2-3	22/09/71				14.3														57.1	28.6						98
AC1-1	13/09/71				100																					28
AC1-2	13/09/71				14.3						42.9		28.6							14.3						109
AC1-3	13/09/71				33.3														33.3	33.3						42
JC1-1	05/09/71			10.5	10.5			21.1											42.1	15.8						296
JC1-2	05/09/71			3,7	18.5	63.0							7.4						7.4							421
JC1-3	05/09/71	11.1		11.1	11.1	11.1		11.1											55.6							140
JC2-1	05/09/71				75														25							125
JC2-2	05/09/71			5,7		2.9							85.7						5.7							546
JC2-3	05/09/71												100													16
PC1-1	05/09/71																		100							109
PC1-3	05/09/71											50							50							31
PC2-1	13/09/71																		56	44						350
PC2-2	13/09/71												94.4						5.6							281
PC2-3	13/09/71																		16.7	83.3						84

Table III. Mackenzie Delta - dredge samples, 1971. (continued)

Station	Date	Nematoda	Hirudinea	Oligochaeta	Gastropoda	Pelecypoda	Isopoda	Amphipoda	Odonata	Plecoptera	Ephemeroptera	Hemiptera	Trichoptera	Coleoptera	Misc. Diptera	Tipulidae	Simuliidae	Chaoboridae	Chironomidae	Ceratopogonidae	Empididae	Acarina	Polychaeta	Cumacea	Tabanidae	Mean Number/m^2
PC3-1	13/09/71											100														112
PC3-2	13/09/71				100																					16
PC3-3	13/09/71				14.3	28.6							14.3						28.6	14.3						98
Table IV Yukon Territory - Surber samples, 1971.																										
Bluefish River																										
#2	14/08/71			2.9		0.2				0.4	4.1		0.7			1.6			89.4			1.8				1586
#3	14/08/71			0.8	4.2	3.9		12.3					1.8						66.4	9.4		1.0				1367
#4	15/08/71				24.8														75.2							27
#5	15/08/71		1.6	71.8							3.4					1.6	3.4		5.1			13.5				212
#6	15/08/71		1.4	29.0						2.9	37.6					7.2			21.7							248
Driftwood River																										
#8	16/08/71			2.6				1.0		2.6	3.1		0.5			4.1	0.5		83.0			3.1				696
#9	16/08/71			1.2				20.0		3.0	10.3		7.9			1.8	0.6		42.4			12.7				592
#10	16/08/71			6.5							33.3					6.5	20.0		33.3							54
#11	16/08/71							4.6		9.4	14.3					4.6			61.9			4.6				75
Eagle River																										
#35	21/08/71			22.0						10.8						10.8						55.4				32
Rat River																										
#37	21/08/71			3.7				1.6		15.4	43.9						11.4		23.6			6.5				441
Bell River																										
#40	21/08/71		0.3							2.4	28.8						22.4		43.6			2.4				1184
#41	21/08/71			2.0						13.7	43.8					0.9	0.7		38.7			0.2				1596
#43	23/08/71									26.6	33.3		20.1			6.5						13.2				54
Fishing Branch																										
#25	20/08/71			3.3				34.4		11.1	7.8		11.1				1.1		15.5			15.5				323
#26	20/08/71									32.3	50.2								21.5							104

Table IV. Yukon Territory - Surber samples, 1971.

Station	Date	Nematoda	Hirudinea	Oligochaeta	Gastropoda	Pelecypoda	Isopoda	Amphipoda	Odonata	Plecoptera	Ephemeroptera	Hemiptera	Trichoptera	Coleoptera	Misc. Diptera	Tipulidae	Simuliidae	Chaoboridae	Chironomidae	Ceratopogonidae	Empididae	Acarina	Polychaeta	Cumacea	Tabanidae	Mean Number/m^2
Cody Creek																										
#24	20/08/71			17.2						43.7	6.2		4.7			3.1	1.5		6.2			17.2				230
Johnson Creek (Porcupine)																										
#30	20/08/71			6.0						13.2			1.2			2.4			32.5			44.6				298
Berry Creek																										
#22	19/08/71									46.2	10.8	1.6	4.6						27.7			9.2				233
Rat Indian Creek																										
#23	19/08/71									17.1						8.4	8.4		36.1							129
Porcupine River																										
#28	20/08/71									18.5	18.5		5.6			1.8			46.3			13.0				194
#45	23/08/71			63.4							8.9						26.8		0.9							402
Old Crow River																										
#14	18/08/71			29.6						15.5	14.1		8.9			2.9			25.2			3.7				484
#15	18/08/71									46.6			20.1			26.6						6.5				54
#47	23/08/71			3.0						1.4	8.9		5.9				13.4		61.1			5.9				240
#57	25/08/71									8.6	4.3	1.4				1.4			81.4			2.8				251
#58	25/08/71			42.5	0.3					19.7	7.4		2.0				1.7		23.7			2.7				1073
#59	25/08/71			3.8						22.1	22.8		0.4			3.4			43.0			4.6				944
#60	25/08/71			5.8		0.2				19.8	3.5		11.1			0.2	0.2		54.3			4.8				2027
Firth River																										
#48	24/08/71			53.0						8.1	16.3					2.0	8.1		10.2			2.0				176
#50	24/08/71			57.9						15.8	7.9		15.8									2.6				136
Babbage River																										
#51	24/08/71			11.8						4.4	3.0						2.2		74.1							484
#53	24/08/71			9.5						13.9	55.6					0.8			17.4			2.6				413
#54	24/08/71			0.4	0.8	0.8				6.0	13.5		1.2			4.8	33.0		35.0			4.4				900

Table V. Peel River and other NWT drainages, 1971.

Station	Date	Nematoda	Hirudinea	Oligochaeta	Gastropoda	Pelecypoda	Isopoda	Amphipoda	Odonata	Plecoptera	Ephemeroptera	Hemiptera	Trichoptera	Coleoptera	Misc. Diptera	Tipulidae	Simuliidae	Chaoboridae	Chironomidae	Ceratopogonidae	Empididae	Acarina	Polychaeta	Cumacea	Tabanidae	Mean Number/m^2
Stony Creek																										
#62	29/08/71									41.5	33.2								25.1							43
#63	29/08/71			4.0						12.0	18.6					1.3	1.3		61.3			1.3				269
#99	11/09/71			22.6				3.1		58.1	3.1								9.7			3.1				111
Vittrekwa River																										
#64	29/08/71			15.3						54.1	7.5					7.5			15.3							46
#65	29/08/71									16.3	16.3								67.4							22
#66	29/08/71									16.3						16.3			66.5							22
#100	11/09/71									19.8			9.8						39.9			30.2				36
#101	11/09/71									56.8			5.9			5.8			35.3							183
Road River																										
#68	29/08/71									13.9	28.3								57.0							25
#69	29/08/71									19.6	60.3								19.6							18
#102	11/09/71			30.4						39.2	15.2								13.0			2.1				165
Trail River																										
#88	08/09/71			49.5						30.2	5.4					2.7			10.1			2.0				534
#89	08/09/71			49.6							24.5								24.5							14
#103	11/09/71			50.0						18.4	10.5								13.0			7.9				136
Caribou River																										
#83	08/09/71									62.4									37.6							57
#87	08/09/71									24.8	62.6								12.2							29
#104	11/09/71										39.7					60.3										18
Mountain Creek																										
#85	08/09/71									75.2						12.2			12.2							29
#97	09/09/71			13.2						13.2	6.5								66.5							54
Satah River																										
#105	11/09/71									50.2			16.3						33.0							22

Table V. Peel River and other NWT drainages, 1971. (continued)

Station	Date	Nematoda	Hirudinea	Oligochaeta	Gastropoda	Pelecypoda	Isopoda	Amphipoda	Odonata	Plecoptera	Ephemeroptera	Hemiptera	Trichoptera	Coleoptera	Misc. Diptera	Tipulidae	Simuliidae	Chaoboridae	Chironomidae	Ceratopogonidae	Empididae	Acarina	Polychaeta	Cumacea	Tabanidae	Mean Number/m^2
Bonnet Plume																										
#95	09/09/71									41.3	47.1						1.4		10.3							243
Wind River																										
#96	09/09/71									52.0	25.3						2.6		20.0							269
Sainville River																										
#72	31/08/71									50.0									50.0							7
Cranswick River																										
#78	05/09/71									88.8	16.7								22.1			5.4				65
Lower Beaver Creek																										
#75	31/08/71									34.6	3.8								57.7			3.8				93
Weldon Creek																										
#76	05/09/71			5.8						47.1	5.8		14.7						20.6			5.8				122
Ontaratue River																										
#110	14/09/71																									0
Rampart River																										
#108	11/09/71									8.0	2.0		25.8						62.7			1.5				721
#107	11/09/71									24.5									75.5							14
Hume River																										
#106	11/09/71																		100							72
Arctic Red River																										
#71	31/08/71									50.0							50.0									8
#115	14/09/71																									0

APPENDIX IV

Supplementary data from studies on the Mackenzie Highway in the Fort Simpson region, 1972.

The Martin River Study

Studies of the impact of highway construction on benthic ecology can be used to predict the effects of pipeline construction on benthos because many features of construction are shared. Watershed clearance for rights of way, bank alterations and stream crossings by heavy machinery, and the possibility of long-term erosion are some of these common features and each of these can have detrimental effects on the flora and fauna of the affected waterway. With this in mind an area of incipient highway construction, the Martin River, was studied.

Plans for the construction of the Mackenzie Valley Highway were announced in May, 1972. Construction was to begin immediately at Fort Simpson on the southernmost fifty miles of the highway. The first river of any size to be crossed was the Martin. It is a humic colored river of small discharge draining Antoine Lake, the Martin Hills, and muskeg areas stretching for about 65 km to the southwest and entering the Mackenzie River about 16 km downstream from Fort Simpson. The Martin carried the highest suspended sediment load of the 5 small rivers studied in the Fort Simpson area, although its suspended sediment load was about 2 orders of magnitude less than the nearby large rivers (Mackenzie, Liard, Redstone).

The following physical and chemical analyses of water, taken upstream and downstream of the highway crossing, were done: discharge, suspended sediment, dissolved oxygen, conductivity, pH, HCO_3^-, $SO_4^=$, TDP, TDN, Cl^-, Si, Ca^{++}, Mg^{++}, Na^+, and K^+.

With the methods in use, gross differences in physical and chemical parameters were not readily discernible between areas of river upstream and downstream to the road crossing. The seeming lack of effect of highway construction (including right of way clearance, the resultant slumping of a bank, and construction activity back and forth across the river) on physical and chemical parameters of the water of the Martin River may be for two reasons:

1. The river is capable of assimilating the particular magnitude of disturbance by highway construction at that crossing site.

2. The effects are delayed. A lag period of approximately five months was found in the Hubbard Brook experimental watershed work (Likens _et al_, 1970). The lag period in the north may be even longer.

Unfortunately, analyses of benthic invertebrate samples are largely incomplete. These results that are available will be considered as follows:

1. Differences between upstream and downstream stations.

2. Drift studies: the effect of net positions in the river on collection of drift.

Table I gives the sums of invertebrates in taxa collected by three Surber samples both upstream and downstream of the highway crossing for July 20 and September 14, 1972. The disparity in total numbers of invertebrates between Stations A and B (Fig. 1) is most likely due to the different nature of the riffle areas from which the samples were taken. The riffle at A was slow moving, had a substrate composed of heterogenous rock sizes, and was visibly silty while the riffle at B was fast-flowing, had a substrate composed of more uniform rock sizes, and was visibly clearer. With the exception of seasonal changes in abundance of taxa, the only differences between the two

sampling dates were in the Oligochaeta, Ephemeroptera, and Coleoptera. However, the dominant taxon, the Chironomidae, retained a similar relationship at each station for both dates. There was no obvious evidence of disruption at Station B.

Figs. 2 and 3 show differences in numbers of organisms captured by the four drift nets used at each station. In an attempt to study lateral and vertical differences in drift in the Martin River, available data from Station A about a month apart and at approximately the same time of day were compared as were data from Station B for two consecutive netting periods in the same day. Figs. 4 and 5 break down each two-hour catch period into numbers of individuals caught per net for the most common taxa. Table II and III give discharge values for each net for each sampling date.

Differences in organisms caught among nets can have several possible explanations:

1. Variations in discharge through the nets in different sections of river.

2. Differences in temporal and spatial distributions of invertebrates in the river and/or in the drift.

3. Differences in behaviour of invertebrates while in the drift.

For example, perhaps the most obvious qualitative difference is that nets which break the surface of the water will collect more allochthonous drift than completely submerged nets. This not unexpected result can be seen in Figs. 4 and 5.

There was not a direct relationship between total numbers of organisms caught per net and net discharge for the July sampling for Station A, but the highest and lowest discharge corresponded to the highest and lowest catches during the August sampling date (see Figs. 2 and 3 and Table II).

For Station B, however, the order was directly related to discharge (see Fig. 3 and Table III). Work by various authors has shown that given a sufficient number of drift samplings, a linear regression can be drawn between drift and discharge (For example, see Elliott, 1970). Note that the order of numbers of invertebrates collected per net stayed the same for Stations A and B for all samplings (highest to lowest for A is 1:2:4:3; for B it is 1:3:2:4). For B this order followed the order of net discharges but for A, other explanations must be sought.

Of the taxa considered, only the Ephemeroptera at Station B were collected in numbers that followed net discharge order. Also, Ephemeroptera were collected in highest numbers at both stations at net #1. Chironomidae and Simuliidae; and Ephemeroptera, Trichoptera, Chironomidae, and Hydracarina were the only taxa collected in all four nets of Stations A and B respectively.

The elucidation of other trends in the vertical and lateral distribution of drifting organisms in the Martin River, as well as definite conclusions regarding the statements made above, will have to await analyses of the remainder of the samples.

Table I Total numbers of invertebrates in Surber samples from the Martin River upstream (A) and downstream (B) of the highway crossing on July 20 and September 14, 1972.

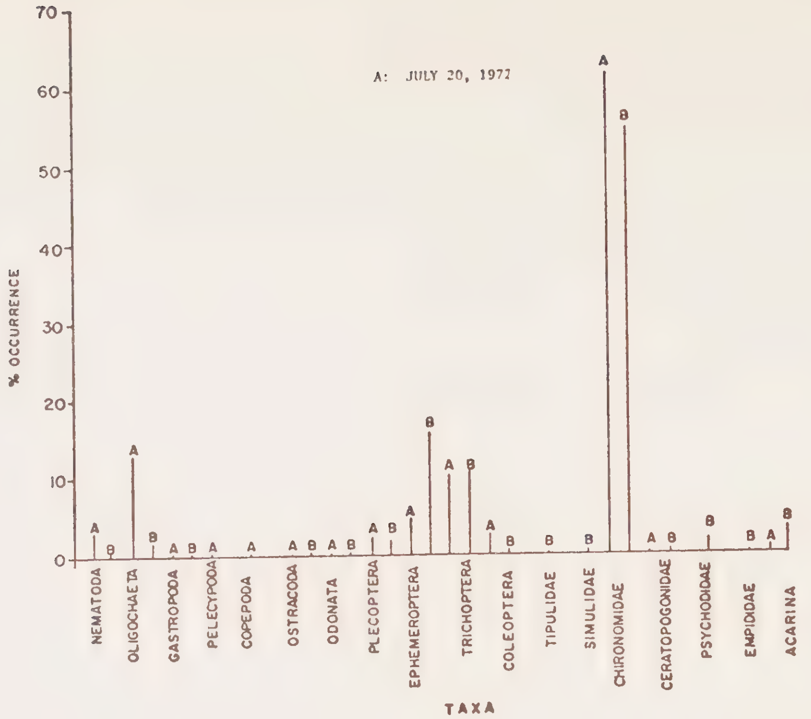
TAXON	STATION A		STATION B	
	July 20	Sept. 14	July 20	Sept. 14
Nematoda	43	11	1	9
Oligochaeta	179	20	16	9
Gastropoda	1	1	3	7
Pelecypoda	1	0	0	1
Copepoda	2	0	0	0
Ostracoda	4	0	2	0
Odonata	2	0	1	0
Plecoptera	34	34	17	35
Ephemeroptera	65	242	137	178
Trichoptera	143	77	95	102
Coleoptera	39	22	60	100
Tipulidae	0	0	1	4
Simuliidae	0	1	7	3
Chironomidae	856	1734	474	1114
Ceratopogonidae	6	9	5	10
Psychodidae	0	0	19	0
Empididae	0	12	2	2
Acarina	16	16	30	17
Total	1391	2179	870	1591

Table II · Discharge through drift nets at Station A on the Martin River.

DATE AND TIME		DISCHARGE (m^3/sec) NET 1	2	3	4
July 19/72	1900-2100	.00205	.00204	.00207	.00151
Aug. 18/72	1300-1700	.00341	.00313	.00296	.00336

Table III Discharge through drift nets at Station B on the Martin River.

DATE AND TIME		DISCHARGE (m^3/sec) NET 1	2	3	4
Aug. 18/72	1300-1700	.00365	.00251	.00363	.00142



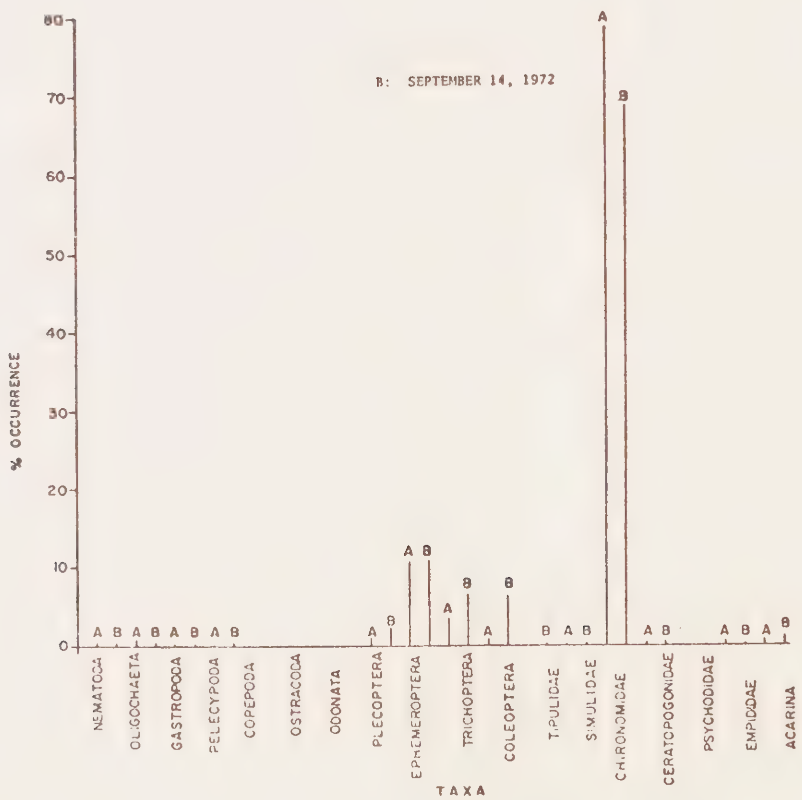


Figure 1: Percent occurrence of taxa in surber samples from the Martin River, Upstream (A) and Downstream (B) of The Highway Crossing.

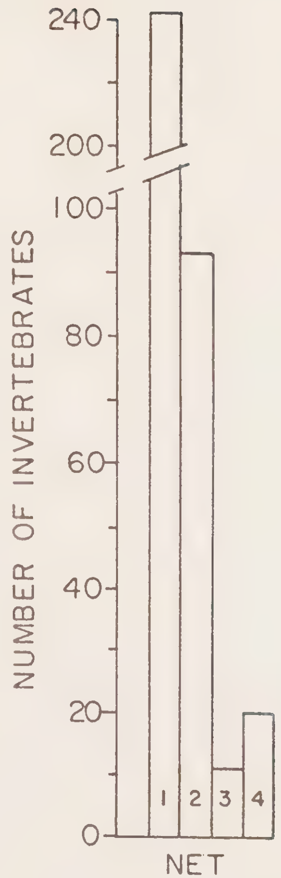


Fig. 2: Numbers of invertebrates captured per net at station A on the Martin River for July 19, 1972.

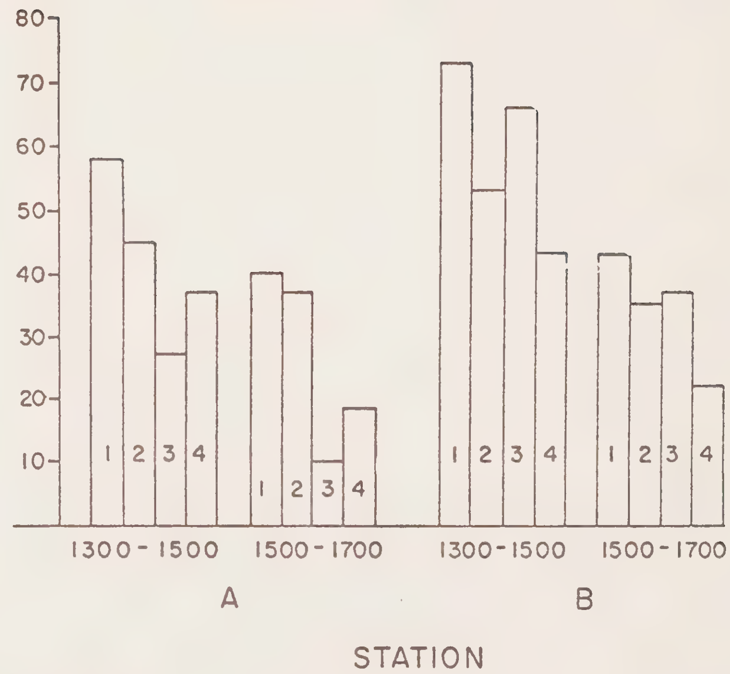


Fig. 3. Numbers of invertebrates captured per net at stations A and B on the Martin River for August 18, 1972.

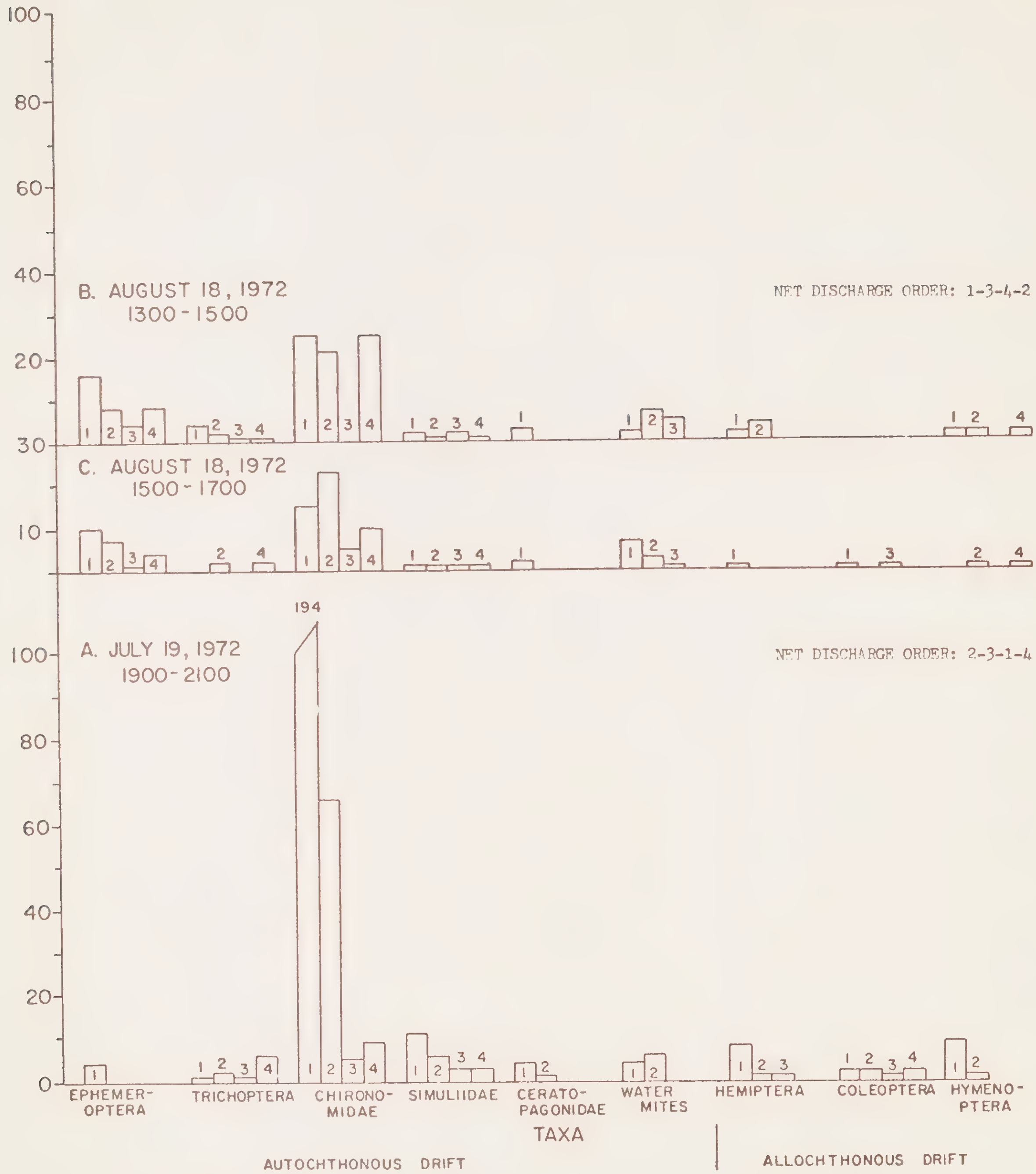


FIG. 4: Numbers of invertebrates collected in each net position for station A on the Martin River on July 19, 1972 and August 18, 1972.

FIG. 5: Numbers of invertebrates collected in each net position for station B on the Martin River on August 18, 1972.

APPENDIX V

Species List of Aquatic Plants and Animals Collected from the Mackenzie and Porcupine River Watersheds in 1971-1973, together with Notes on Their Abundance and Distribution

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N. B. Snow
G. L. Vascotto

APPENDIX V TAXON LIST

Each taxon is followed by the station location (as per abbreviation used in Appendix 1 and add AL = Airport Lake, Inuvik; and FS - Fort Simpson area) and date of collection (1971 and/or 1972). Square brackets separate Yukon, Delta, and mainstem locations, respectively.

A. Plants - all dates are 1972.

1. Benthic algae - no Delta data reported.

Achnanthes minutissima Kütz [CC] [JM]
Anomoneis vitrea (Grun) Ross [-] [FS]
Bulbocheata sp. [CC] [-]
Chaetophora cf. pisciformis [CC] [-]
Closterium sp. [CC] [-]
Cocconeis placentula Ehr. [-] [FS]
Cosmarium spp. [CC] [-]
Cymbella cf. turgida (Greg.) Cleve [CC] [-]
Cymbella turgida (Greg.) Cleve [-] [FS]
Cymbella cf. ventricosa Kütz [CC] [FS]
Diatoma elongatum (Lyngb.) Agardh. [CC] [JM]
Fragillaria construens (Ehr.) Grun. [CC] [-]
Fragillaria intermedia Grun. [CC] [-]
Fragillaria spp. [CC] [FS]
Gomphonema angustatum (Kütz) Rabb. [-] [HR]
Hanneae arcus (Ehr.) Patr. [CC] [-]
Meridion circulare (Grec.) Ag. [CC] [-]
Microspora sp. [CC] [-]
Mougeotia sp. [CC] [-]
Navicula spp. [CC] [-]
Nitschia acicularis W. Smith [-] [FS]
Nitschia amphibia Grun. [CC] [FS]
Nitschia spp. [CC] [-]
Rhopalodia gibba (Ehr.) O. Müll. [-] [FS]
Staurastrum spp. [CC] [-]
Synedra amphicephala var. austriaca (Grun.) Hurt. [-] [FS]
Synedra spp. [CC] [-]
Synedra ulna (Nitzshia) Ehr. [CC] [TR]
Synedra ulna var. danica (Kütz) V. H. [CC] [-]
Tabellaria flocculosa (Roth.) Kütz [CC] [-]
Zygnema sp. [CC] [-]

2. Macrophytes - no Yukon data reported.

Alisma plantago - aquatica L. [-] [JM]
Beckmannia borealis (Steud.) Fern. [-] [SR]
Calamagrostis inexpansa A. Gray [-] [JM;MA;MR]
Calamagrostis neglecta (Ehrh.) Gaertn., Mey, & Schreb [A1;SL1] [-]
Calla palustris L. [A1;L4] [-]
Callitriche hermaphroditica L. [AL;L4;LC4;SL1] [HR;MA;RR;SR;TO]
Callitriche verna L. [-] [HR]
Carex aquatilis Wahlenb. [AL;L4;LC4;SL1] [JM;MA;MR]
Carex diandra Schrank [AL] [-]
Carex rostrata Stokes [-] [MA;SR]
Ceratophyllum demersum L. [L5;L7] [-]
Chara globularis Thuill. [AL;L4;LC4] [HR;RR]
Chara sp. [-] [MA;TO;WL]
Chara vulgaris L. [L5] [JM;MR]
Cicuta douglasii (D.C.) Coult. & Rose [AL] [MA]
Eleocharis acicularis (L.) R. & S. [L4;LC4] [-]
Eleocharis palustris (L.) R. & S. [-] [JM;MA;RR;SR;TO]
Galium laboradoricum (Weig.) Weig. [-] [JM]
Galium trifidum L. [AL] [-]
Glyceria borealis (Nash) Botch. [-] [SR]
Hippuris vulgaris L. [AL] [JM;MR;RR;TO]
Juncus balticus Willd. [-] [MA;MR]
Juncus nodosus L. [-] [JM;MR]
Lemna trisulca L. [AL;L7;SL1] [-]
Menyanthes trifoliata L. [AL] [-]
Myriophyllum spicatum L. [AL;L4;L5;L7] [HR;JM;MA;RR;SR;TO]
Nitella flexilis (L.) Ag. [L4;L5] [HR]
Nuphar variegatum Engelm. [SL1] [-]
Phalaris arundinacea L.[-] [RR]
Polygonum amphibium L. [-] [JM;SR]
Potamogeton alpinus Balbis [AL] [HR;JM;MA;TO;WL]
Potamogeton filiformis Pers. [L4] [JM]
Potamogeton gramineus L. [-] [JM;MR;RR;SR;TO]
Potamogeton pectinatus L. [AL;L5;LC4;L4] [MR;SR;TO]
Potamogeton praelongus Wulf. [AL;L5;L7] [-]
Potamogeton pusillus L. [L4;LC4] [JM;TO]
Potamogeton richardsoni (Benn.) Rydb. [AL;L4;L5;L7;LC4;SL1] [HR;JM;MA;MR;RR;SR;TO;WL]
Potamogeton vaginatus Turcz. [L1] [JM;MA;RR;SR;WL]
Potamogeton zosteriformis Fern. [L5] [-]
Potentilla palustris (L.) Scop. [AL;L4;LC4;SL1] [-]
Ranunculus aquatilis L. [SL1] [MA;RR]
Ranunculus gmelinii D.C. [L4;SL1] [-]
Sagittaria cuneata Sheldon [L4;LC4] [JM;RR;SR]
Sium suave Walt. [-] [JM;SR]
Sparganium angustifolium Michx. [SL1] [HR;MR;RR;WL]
Sparganium minimum (Hartm.) [L4] [-]
Tolypella sp. [-] [JM;RR]
Triglochin maritima L. [-] [JM;RR]
Utricularia intermedia Hayne [-] [JM]

Utricularia vulgaris L. [AL; L4] [JM; SR]
Zannichellia palustris L. [-] [MA; TO]

B. Invertebrates

1. Hoplonemertea - Delta data only

Artacama proboscidea Malmgren [BS26-72]
Tetrastemma? [BS26-72]

2. Nematoda - no Yukon data reported.

Aporcelaimus sp. [-] [MR72]
Axonolaimus sp. [KU72] [-]
Budorylaimus sp. [EC72] [-]
Dorylaimus sp. [CC72; EC72; GC72; KU72; L372; L472; L572; L1172; LC472; WC72] [TR71; JM72; MR72]
Dorylaimus stagnalis [CC72; EC72; GC72; L372; L472; L572;LC472] [MR72]
Eudorylaimus sp. [-] [JM72; MR72; RR72]
Mononchus niddensis [L472; LC472] [MR72]
Sphaerolaimus sp. [BS72; KU72] [-]
Tobrilus sp. [L472; L572; LC472] [-]
Tripyla sp. [L472] [TR72]

3. Annelida

a) Polychaeta - Delta data only

Ampharete göesi Malmgren [BS14-71; BS26-72; KU72]
pos. Nainereis quadricuspidata (Fabr.) [BS19-71]
Petaloproctus tenuis (Théel) [BS19-71]
Spio filicornis (Muller) [BS15-71; BS19-71; KU71; KU72]

b) Oligochaeta

Aulodrilus americanus Brinkhurst & Cook [-] [GC72] [-]
Cernosvitoviella sp.?[CC72] [-] [MR71; TR71; MR72]
Cernosvitoviella sp. 1 [-] [-] [TR71]
Chaetogaster cristallinus Vejdovsky [-] [-] [HR71]
Eiseniella tetraedra (Savigny) [-] [-] [HR71]
Fidericia sp. [20-71] [-] [-]
Henlea sp. [20-71; 54-71] [MC72] [MR72]
Ilyodrilus templetoni? (Southern) [-] [LC472] [-]
Limnodrilus claparedeianus Ratzel [-] [CC72; EC72; LC472; L172; L372; L572] [-]
Limnodrilus hoffmeisteri Claparede [-] [EC72; LC472; L172; L372; L572; SL172] [-]
Limnodrilus profundicola (Verrill) [-] [CC72; EC72; MC72; WC72][-]
Limnodrilus sp. [-] [CC72; EC72; LC472; L4C72; L572] [MR71; MR72]
Limnodrilus udekemianus Clapareda [-] [GC72; LC472; L572] [-]

Lumbricillis sp. [-] [EC72; WC72][-]
Lumbriculidae n. sp. 1 [8-71; 30-71; 37-71; 38-71; 45-71;50-71;CC72][-][-]
Lumbriculidae n. sp. 2 [8-71; 45-71; 58-71] [-] [-]
Lumbriculidae sp. A. [-] [-] [HR71]
Lumbriculus variegatus (Müller) [19-71; CC72][CC72;L572][HR71;JM71; MR71; RR72]
Lumbriculus variegatus inconstans (Smith) [-] [L572] [-]
Mesenchytraeus sp. [48-71; 50-71; CC72] [-] [-]
Nais behningi Michaelsen [-] [-] [HR71; MR71]
Nais communis Piguet [-] [-] [HR71;MR71;TR71]
Nais pseudobtusa? Piguet [-] [-] [MR71]
Nais simplex Piguet [45-71] [-] [HR71; MR71; TR71]
Nais variabilis Piguet [-] [-] [HR71; TR71]
Paranais litoralis (Müller)* [-] [-] [MR72]
Peloscolex sp. [-] [L472; L4C72] [-]
Pristina foreli (Piguet) [-] [-] [HR71; MR71; TR71; MR72]
Pristina idrensis Sperber° [-] [-] [HR71]
Rhyacodrilus coccineus [-] [CC72] [-]
Rhyacodrilus sodalis Eisen [-] [-] [JM71]
Rhynchelmis sp. 1 [8-71; 30-71; 48-71; 50-71; 56-71; 58-71; CC72; LC72] [LC472] [-]

*Previously reported only from brackish water.
o North American record

Slavina appendiculata (Udekem) [-] [-] [HR71;TR71]
Stylaria lacustris (Linnaeus) [-] [CC72] [MR71;TR71]
Stylodrilus n. sp. 1 [44-71; 45-71; BR72][EC72; WC72] [-]
Tubifex kessleri americanus Brinkhurst & Cook [-] [CC72; EC72] [-]
Tubifex sp. [-] [L472] [-]
Tubifex tubifex (Müller) [-] [LC472] [-]
Tubificinae n. sp. 1 [CC72] [-] [-]
Tubificinae n. sp. 2 [CC72] [L1172][-]
Uncinais uncinata (Orsted) [-] [-] [TR71]

4. Crustacea

a) Mysidacea - Delta data only

Mysis sp. af. relicta Loven [BS24-71]
Neomysis mercedis Holmes [EC71]

b) Cumacea - Delta data only

Diastylis sulcata Calman [BS19-71; KU71; BS26-72; KU72]

c) Isopoda - Delta data only

Saduria entomon (Linnaeus) [BS15-72; KU72]
Saduria sabini (Kroyer) [BS13-72; KU72]

d) Amphipoda - Delta data only

Anonyx sp. af. lilljeborgi Boeck [BS24-71]
Boeckosimus birulai (Gurjanova) [BS24-72]
Lysianella petalocera Sars [BS15-72]

Pontoporeia affinis Lindstrom [BS15-71; KU71; BS15-72; BS26-72; EC72; KU72]
Pontoporeia femorata Kroyer [BS15-71; BS26-72; KU72]
Priscilina armata Boeck [BS15-72]

e) Ostracoda

Candona actula Delorme [-] [L472] [-]
Candona acuminata (Fischer) [-] [L771; L572] [-]
Candona bretzi Staplin [-] [L572; LC472] [-]
Candona candida (Müller) [-] [GC72] [TR71]
Candida compressa (Koch) [-] [GC72] [TR71]
Candona distincta Furtos [-] [CC72] [-]
Candona pedata Alm [-] [L572] [-]
Candona protzi Hartwig [-] [L471; L1172; L1272; LC472] [-]
Candona rawsoni Tressler [-] [EC72; GC72; L572; MC72; WC72] [-]
Candona rectangulata Alm [-] [LC472; MC72] [-]
Candona sp. [-] [CC72; EC72; GC72; L372; L572; LC472; MC72; WC72] [TR71; MR72]
Candona willani Staplin [-] [MC72] [-]
Candocyprinotus ovatus Delorme [-] [CC72] [-]
Cyclocypris ampla Furtos [BR71] [L271; CC72; EC72; L472; L572; L1172; L1272; LC472; MC72; WC72] [MR72]
Cyclocypris laevis (Müller) [-] [CC72; EC72] [MR72]
Cyclocypris serena (Koch) [-] [MC72] [MR72]
Cyclocypris sharpei Furtos [-] [CC72; LC472] [MR72]
Cypria ophthalmica (Jurine) [BR71; JC72; LC72] [L471; L771; CC72; EC72; GC72; L372; L472; L572; L772; L1172; L1272; LC472; WC72] [MR72]
Cypria sp. [-] [WC72] [-]
Cypricercus reticulatus (Zaddach) [-] [L1172] [-]
?Cypricerous sp. [-] [-] [MR72]
Cypridopsis vidua (Müller) [-] [CC72; L572] [-]
Limnocalnus macrurus grimaldi (Gulme) [-] [BS26-72] [-]
Lymnocythere sp. [-] [-] [TR71]
Megalocypris alba (Dobbin) [-] [L271; L771] [-]

5. Insecta

a) Ephemeroptera

Ameletus prob. sparsatus McDunnough [-] [-] [MR72]
Ameletus sp. [BR72] [-] [TR72]
prob. Ameletus sp. [CC72; BR72] [-] [RR72]
Arthroplea sp. [-] [-] [MR71]
Baetis prob. vagans McDunnough [-] [-] [MR72]
Baetis sp. [8-71; BR71; CC71; BR72; CC72]
Baetis spp. [-] [-] [MR71; TR71; MR72]
prob. Baetis sp. [CC72] [-] [MR72]
Baetisca sp. [-] [-] [MR72]
Caenis sp. [CC72] [L472; LC472] [JM71; MR72]
prob. Caenis sp. [-] [LC472] [-]
Callibaetis sp. [CC72] [-] [-]
Cinygmula sp. [OC72] [-] [-]

Cloeon sp. [-] [-] [HR71]
prob. Cloeon sp. [CC72][-] [-]
Ephemera simulans Walker [-] [-] [MR72]
Ephemera sp. [-] [-] [JM71; MR71; JM72; MR72; TR72]
Ephemerella excrucians? Walsh [-] [-] [BT71]
Ephemerella invaria (Walker) [-] [-] [PT71]
Ephemerella sp. [BR71; OC71] [EC71; WC71; EC72][JM71; TR71; HR72; JM72; LR72; MR72; PR72; TR72]
Heptagenia maculipennis Walsh [-] [-] [MR72]
Heptagenia pulla (Clemens) [-] [-] [MA71 between FS & RR]
Heptagenia sp. [OC71] [-] [BT71; HR71; JM71; TR71; MR72]
Leptophlebia nebulosa (Walker) [-][-][RR72]
Leptophlebia sp. [-] [SL72] [TR71; HR72; RR72; TR72]
Paraleptophlebia sp. [-] [-] [HR71; MR71; JM72; MR72; RR72; TR72]
Parameletus sp [-] [-] [TR72]
Rhithrogena sp. [8-71; 45-71; 46-71; BR71; CC71: OC71; PR71] [-] [JM72; LR72; MR72]
Rhithrogena undulata (Banks) [-][-] [GB71 @ BD; MA71 @ FS & @ SR & @ RR]
Siphlonurus sp. [CC72] [-] [-]
Siphlonurus cf. alternatus (Say) [-] [-] [GB71 @ BD; MA71 @ Ft. Good Hope & @ Sans Sault Rapids]
Stenonema sp. [-] [-] [JM72; MR72; TR72]
Tricorythodes sp. [-] [-] [HR71; MA71 @ RR & @ SR; RR71]

b) Odonata

Aeshna sp. [-] [L472] [HR71]
Agrion sp. [-] [-] [MR72; RR72]
Coenagrion resolutum (Hagen) [-] [L472] [-]
Coenagrion sp. [-] [L472] [-]
Cordulegastridae [-] [-] [RR72]
Enallagma boreali Selys [-] [CC72]
Enallagma sp. [-] [L722] [-]
Gomphidae [-] [-] [MR72]
Leucorrhinia hudsonica (Selys) [-] [L472] [-]
Leucorrhinia intacta Hagen [-] [L472 [-]
Leucorrhinia sp. [-] [L472] [-]
Libellula sp. [-] [L472] [-]
Ophiogomphus sp. [-] [-] [JM71; JM72; MR72]
Somatochlora sp. [-] [CC72] [-]

c) Plecoptera

Arcynopteryx compacta McLachlan [5-71; PR72] [-] [HR71]
Capnia confusa Claassen [-] [-] [RR72]
Capnia ogotoruka Jewett [2-71] [-] [-]
Capnia sp. [2-71] [-] [MR72; RR72]
Claassenia sabulosa (Banks) [-] [-] [MA71 @ SE & @ TR & @ FS & south of SR; MR71; RR71; TR71; MR72]
Diura sp. [-] [-] [TR71]
Hastaperla brevis (Banks) [-] [-] [JM71; MR71; TR71; HR72; JM72; MR72; TR72]
Hastaperla sp. [CC72] [-] [LR72]
Hastaperla prob. brevis (Banks) [CC72] [-] [-]
Isogenoides frontalis columbrinus Hagen [-] [-] [MA71 @ FS; HR71]
Isogenus (Cultus) sp. [-] [-] [MR72]
Isogenus sp. [2-71; 44-71; 55-71; CC71] [-] [HR71; MR71; TR71; LR72]
Isoperla decolorata Walker [-] [-] [MA71 @ Ft. Good Hope & Sans Sault Rapids & @ TR & @ FS & south of SR: TR71]

Isoperla longiseta Banks [-] [-] [GB71 @ BD; MA71 @ Ft. Good Hope]
Isoperla petersoni Needham & Christenson [-] [-] [GB71 @ BD]
Isoperla sp.[44-71] [MC71; WC71; WC72] [HR71; MR71; JM72; MR72]
Kathroperla sp. [-] [-] [MR72]
Nemoura arctica Esben-Peterson [1-71] [-] [-]
Nemoura sp. [42-71; CC71; CC72] [CC72] [JM72]
Perlodidae [CC72] [-] [LR72; PR72; TR72]
Pteronarcys dorsata Say [OR ?] [EC72] [RR71; TR71; MR72; TR72]
Pteronarcys sp. [-] [-] [MR72]
Suwallia pallidula Banks [-] [-] [BT71]

d) Hemiptera

Arctocorisa chanceae Hfd. [CC71] [-] [-]
Callicorixa alaskensis Hfd. [-] [-] [RR72]
Callicorixa audeni Hfd. [-] [-] [PR72; RR72]
Callicorixa sp. [CC72] [-] [-]
Cenocorixa sp. [-] [-] [RR72]
Cymatia americana Hussey [-] [-] [RR72]
Dasycorixa johanseni (Walley) [-] [L722] [-]
Gerris buenoi Kirk [-] [L472] [-]
Merragata herbroides White [-] [-] [MR72]
Microvelia buenoi Drake [-] [L472] [-]
Sigara alternata (Say) [-] [-] [HR71; MR71]
Sigara conocephala Hfd. [-] [-] [PR72]
Sigara decoratella (Hfd.) [-] [-] [PR72]
Sigara lineata (Forster) [-] [-] [RR72]
Sigara trilineata (Prov.) [-] [-] [PR72; RR72]
Sigara sp. [CC72] [SL172]

e) Coleoptera

Adalia sp. [-] [-] [MR72]
Agonum retractum LeC. [-] [-] [MR72]
Arpedium brachypterum Grav. [-] [KU72] [-]
Atheta sp. [CC72] [-] [-]
Bidessus affinis Say [-] [-] [RR72]
Colymbetes sculptilis Harr. [-] [L472 [-]
Corticaria or Melanophthalma sp. [-] [-] [MR72]
Cymindis cribricollis Dej. [-] [-] [MR72]
Cyphon nebulosus (LeC.) [CC72] [-] [-]
Cyphon prob. variabilis (Thbg.) [CC72?] [-][-]
Donacia sp. [-] [-] [MR72]
Eutheia morae Marsh [CC72] [-] [-]
Eutheia sp. [14-71] [-] [-]
Gynpeta sp. [CC72] [-] [-]
Gyrinus sp. [-] [L772] [-]
Haliplus immaculicollis Harr. [-] [L472; LC472] [-]
Haliplus leechi Wallis [-] [LC472] [-]
Haliplus sp. [3-71] [-] [-]

Helophorus browni McCorkle [BR72] [-] [-]
Hydraena sp. [-] [-] [MR72]
Hydroporus depressus F. [CC71] [-] [-]
Hydroporus melanocephalus Gyll. [CC72] [-] [-]
Hydroporus sp. nr. obesus Lec. [CC72] [-] [-]
Hygrotus sayi Balf. [-] [-] [RR72]
Hypolithus bicolor Esch. [-] [-] [MR72]
Lordithon rubescens Hatch [CC72] [-] [-]
Malachius sp. [-] [-] [MR72]
Ochthebius holmbergi Mannh. [-] [-] [MR72]
Ochthebius interruptus LeC. [-] [-] [RR72]
Ochthephilus n. sp. [CC72] [-] [-]
Olophrum rotundicolla (Sahlb.) [CC72] [-] [-]
Optioservus fastiditus LeC. [-] [-] [HR71; TR71; MR72; RR72]
Optioservus sp. [-] [-] [HR71; MR71; TR71; MR72; RR72; TR72]
pos. Oreodytes sp. [6-71] [-] [-]
pos. Paracymus sp. [-] [-] [HR71]
Philonthus sp. [-] [-] [HR71]
Podabrus sp. [CC72] [-] [-]
Porrhodites fenestralis(Zeh.) [6-71] [-] [-]
Reesa vespulae (Milliron) [-] [KU72] [-]
Zaitzevia sp. [-] [-] [MR72]

f) Trichoptera

Agapetus sp. [5-71] [-] [HR71; TR71; RR72; TR72]
Agrypnia straminea Hagen
or Banksiola selina Betten [-] [CC72; L572; L772; SL72]
Agraylea multipunctata Curtis [-] [-] [HR71]
Agraylea sp. [-] [-] [HR71]
Apatania sp. [-] [-] [BT71]
Arctopsyche sp. [-] [-] [LR72; TR72]
Athripsodes sp. [-] [CC72; L772] [HR71; MA71; MR71; TR71; MR72; RR72; TR72]
Banksiola sp. [-] [CC72] [RR72]
Brachycentrus sp. [13-71; BR71; CC71; CC72] [-] [HR71; TR71; MR72; TR72]
Cheumatopsyche sp. [-] [-] [MR72]
Ecclisomyia sp. [-] [-] [TR72]
Glossosoma sp. [CC71] [-] [HR71; TR71;MR72; TR72]
Glossosoma velona Ross [-] [-] [MA71 - south of SR]
Glyphotaelius sp. [-] [L472; LC472] [-]
Helicopsyche sp. [-] [-] [HR71]
Helicopsyche borealis Hagen [-] [-] [HR71]
Hydropsyche sp. [42-71] [EC71;EC72] [HR71; MR71; TR71; MR72; PR72; TR72]
Hydroptila consimilis Morton [-] [-] [MA71 - south of SR]
Hydroptila sp. [-] [-] [HR71; MR72; RR72; TR72]
Lepidostoma sp. [17-71; CC72] [JM71; TR71; MR72; RR72; TR72]
prob. Lepidostoma sp. [CC72] [-] [-]
Lepidostoma togatum (Hagen) [-] [-] [MA71 - south of SR]
Limnephilus sp. [5-71] [-] [MR71]

Mystacides sepulchralis Walker [-] [-] [HR71]
Mystacides sp. [-] [-] [TR71; MR72]
Neureclipsis bimaculatus (Linnaeus) [-] [-] [MA71 - south of SR]
Neureclipsis prob. bimaculatus (Linnaeus) [-] [GC72] [-]
Neureclipsis sp. [-] [WC71; EC72] [JM71; MR71; TR72]
Oecetis sp. [3-71] [L471;CC72] [JM71; MR72; TR72]
Oxyethira sp. [-] [-][HR71; MR72; TR72]
Phryganea sp. [-] [L471; CC72; L472] [-]
Phryganeid Ge. A. [-] [L472; LC472] [-]
Platycentropus sp. [CC72] [-] [MR72]
Polycentropus remotus Banks [-] [-] [MR72]
Polycentropus sp. [CC72] [EC72] [HR71; MR72; TR72]
Psychomia sp. [-] [-] [MR72]
Pycnopsyche guttifer (Walker) [-][-] [PT71]
Radema nr. stigmatella (Zett.) [-][-] [GB71]
Rhyacophila sp. [CC72[[-] [MR72; TR72]
Stactobiella sp. [CC71] [-] [MR72; PR72]
Wormaldia sp. [-] [-] [JM72; MR72]

g) Lepidoptera

prob. Pyrausta [-] [-] [MR72]

h) Diptera

(i) Tipulidae

Arctoconopa sp. [-] [WC72] [-]
Dicranota sp. [6-71; CC71; CC72] [-] [MR71; JM72]
Erioptera sp. [-] [-] [MR72]
Eriopterini [CC72] [-] [MR72]
Hexatoma spp. [6-71; BR72] [-] [JM71; MR72]
Limnophila sp. [CC72] [-] [MR72]
Prionocera sp. [-] [L472] [-]
Tipula bergrothiana Alex. [-] [WC72] [-]
Tipula sp. [7-71; 8-71; BR71; CC72] [L472] [HR71; MR71]

(ii) Culicidae

Aedes communis (DeGeer) [-] [L472; LC472] [-]
Aedes earlei Vargas [-] [-] [RR72]
Aedes excrucians (Walker) [-] [LC472] [-]
Aedes fitchii grp. [-] [L472; LC472] [-]
Aedes sp. [-] [-] [RR72; TR72]
Chaoborus flavicans Meigen) [-] [L472; L772] [RR72]
Culex alaskensis (Ludlow) [-] [-] [MR72; RR72]

(iii) Ceratopogonidae

Allaudomyia sp. [-] [-] [MR72]
Atrichopogon sp. [-] [-] [MR72]

Bezzia glabra (Coq.) [3-71] [CC72; L472] [RR72]
Bezzia/Palpomyia [19-71; 73-71; 78-71; 111-71; CC72] [EC71; L471; MC71; NC71; WC71; CC72; EC72; GC72; L172; L372; L472; L572; LC472; MC72; WC72] [JM71;MR71; TR71; MR72; TR72]
Bezzia sp. [-] [L471; L472] [JM71; MR71; TR71; MR72]
Ceratopogon sp. [-] [-] [MR72]
Culicoides sp. [-] [-] [MR72]
Culicoides yukonensis Hoffman [-] [L472] [-]
Dasyhelea sp. [-] [L472] [MR72]
Forcipomyia sp. [-] [-] [HR72; MR72]
Palpomyia/Sphaeromias [-] [LC472] [MR71]

(iv) Chironomidae

1) Tanypodinae

Ablabesmyia [17-71; BR72; CC72] [CC72; EC72; L472; L572; L772; L1172] [HR71; MR71; TR71; MR72; RR72; TR72]
Labrundinia [-] [L472] [MR71; MR72; RR72]
Natarsia [CC72] [GC72] [-]
Nilotanypus [-] [-] [MR72; TR72]
Procladius [3-71; CC71; CC72] [CC72; EC72; L172; L372; L472; L572;L772; L1172; L1272; LC472; MC72; SL172; WC72] [MR71; MR72; RR72]
Procladius subletti Roback [-] [-] [HR71]
Psectrotanypus [3-71; CC72] [-] [-]
Tanypus [-] [L472] [-]
Thienemannimyia sp./grp. [BR71; OC71; CC72; DW72; JC72; LC72] [CC72; GC72] [HR71; MR71; TR71; MR72; RR72]
Trichotanypus [CC72] [-] [-]
Trissopelopia [5-71; 47-71; BR72; CC72; DW72; LC72] [EC72] [MR72; TR72]
Trissopelopia or Thienemannimyia [-] [-] [MR-72]
Zavrelimyia [47-71] [GC72] [HR71; MR72]

2) Chironominae

a) Chiromomini

Acalcarella sp. [-] [L372] [-]
Chironomus [BR71; CC71; CC72] [EC72; L472; L572; L772; L1272; LC472; SL172] [MR71; RR72]
Cryptochironomus [3-71; 19-71; 47-71; JC72] [CC72; L472; L572; LC472; SL172] [MR72]
Cryptochironomus cf. demeigera (Krus.) [BR72] [-] [MR72]
Cryptocladopelma [2-71] [EC72; L172; L472; L572; L1272; LC472; SL172] [-]
Cryptotendipes sp. [-] [L572] [-]
Demicryptochironomus [DW72] [CC72; GC72; L372; WC72] [MR72; TR72]
Dicrotendipes [3-71; OC71; CC72] [CC72; EC72; L472; L572; L772; LC472; SL72] [RR72]
Einfeldia [-] [L472; L572; L772] [-]

Endochironomus [3-71; LC72] [L472; L572; L772] [-]
Glyptotendipes [3 71; CC72; JC72][EC72; L472; L572; L772; SL172] [-]
Harnischia [-] [CC72] [-]
Lauterborniella [-] [L472; LC472] [-]
Lauterborniella agrayloides (Kieff.) [-] [LC472] [-]
Leptochironomus [-] [L1272] [-]
Microtendipes [-] [CC72; L472] [MR72; TR72]
Parachironomus [-] [CC72; L472; LC472; L572] [RR72]
Paraclodopelma [BR72] [CC72: EC72; GC72; L372; MC72; WC72][MR71; MR72]
Paralauterborniella [47-71; DW72; CC72; JC72; LC72] [CC72] [MR71; MR72; RR72]
Paratendipes [-] [CC72 L572] [MR71; TR71; MR72]
Phaenopsectra [44-71; DW72] [CC72; EC72; L772; L1272] [RR72]
Phaenopsectra or Endochironomus [6-71] [-] [-]
Polypedilum (Tripodura) [CC72][-] [-]
Polypedilum [47-71; BR71; BR72; CC72; JC72] [CC72; EC72; GC72; L472; LC472; SLI72; WC72] [MR71; MR72; RR72; TR72]
Pseudochironomus [-] [L472] [RR72]
Stictochironomus [CC72; LC72] [EC72; WC72] [-]
Xenochironomus [LC72] [-] [MR72]

b) Tanytarsini

Cladotanytarsus [3-71; 44-71; 47-71; BR72; CC72][CC72; DW72; EC72; JC72; L472; LC472; SL172] [HR71; MR71; MR72]
Constempellina [-] [CC72] [MR72; TR72]
Micropsectra [1-71; BR72; CC72] [KU71; CC72] [HR71; MR71; MR72; RR72; TR72]
Paratanytarsus [3-71] [L472; L572; L772; L1172; L1272] [-]
Rheotanytarsus [CC71; CC72; LC72] [L472; L1272; LC472] [HR71; TR71; MR72; TR72]
Stempellina [CC72; JC72; LC72] [-] [MR71; MR72]
Stempellinella [LC72] [CC72; L1172; L1272] [HR71; MR72; RR72; TR72]
Tanytarsus [BR71; CC71; BR72; CC72] [CC72; L472; LC472; SL172] [HR71; MR71; MR72; RR72; SL72]

3) Orthocladiinae

Brillia [47-71] [EC72] [TR71; MR72; TR72]
Chaetocladius [CC71; CC72] [L472] [-]
Corynocera [-] [L472; L1272] [-]
Corynocera n. sp. [-] [L1272] [-]
Corynoneura [2-71; 17-71; BR72; CC72: DW72] [-] [HR71; MR71; TR71; MR72; TR72]
Cricotopus [4-71; 8-71; 45-71; CC71; OC71; BR72; CC72; LC72] [CC72; L472; SL72] [HR71; TR71; MR72; TR72]
Diplocladius [CC72] [-] [TR72]
Eukiefferiella [8-71; 12-71; 46-71; BR71; CC71; OC71; PR71; BR72; CC72; LC72; LC472] [-] [MR71; TR71; MR72; RR72; TR72]
Gymnometriocnemus [CC72] [-] [-]
Heterotrissocladius [6-71; CC72] [EC72] [-]
Limnophyes [CC72] [-] [-]
Krenosmittia [CC72; LC72] [-] [MR72]
Metriocnemus [CC72] [-] [-]

Microcricotopus [OC71; CC72; JC72; LC72] [CC72; EC72] [TR72]
Orthocladius [8-71; BR71; CC71; OC71; CC72; LC72] [-] [-]
Orthocladius (Eudactylocladius) [CC72] [L1272] [-]
Orthocladius (Euorthocladius) [CC72] [-] [-]
Orthocladius (Pogonocladius) [-] [L1272] [-]
Orthocladius (S.S.) [OC71] [-] [HR71; TR71]
Orthocladius or Cricotopus [8-71; 42-71; BR71; CC71; OC71; BR72; CC72; DW72; LC72] [CC72; L472; LC472] [TR71; MR72; RR72; TR72]
Parakiefferiella (?) [CC72] [L572] [-]
Parametriocnemus [CC72] [-] [MR71; MR72; TR72]
Psectrocladius [3-71; 17-71; CC72] [CC72; EC72; L472; L572; L772; LC472] [HR71; MR71; TR71; MR72; RR72; TR72]
Rheocricotopus [6-71; CC72] [-] [HR71; MR72; TR72]
Smittia [CC72] [-] [-]
Synorthocladius [CC72] [-] [MR72; RR72; TR72]
Thienemanniella [7-71; OC71; CC72; JC72; LC72] [-] [HR71; TR71; MR72; RR72; TR72]
Trissocladius [BR71; BR72: CC72] [CC72; EC72; L472; LC472] [MR72; RR72]
Trissocladius (=Zalutschia) zalutschicola (Lip) [(Syn.) T. naumanii (Brudi)] [-] [SL72] [-]

4) Telmatogetoninae - Diamesini

Diamesa [8-71; BR71; CC72] [-] [-]
Pagastia [44-71] [-] [-]
Potthastia [2-71; CC72; LC72] [CC72; GC72] [HR71; MR72]
Prodiamesa [6-71] [EC72; WC72] [-]
Sympotthastia [2-71] [-] [RR72]

(v) Simuliidae

Cnephia sp. [CC72] [-] [HR72]
Eusimulium sp. [CC72] [-] [-]
Prosimulium perspicuum Sommerman [8-71] [-] [-]
Prosimulium prob. perspicuum Sommerman [44-71] [-] [-]
Prosimulium sp. [BR72; CC72; LC72] [-] [HR72; MR72; TR72]
prob. Prosimulium sp. [CC72] [-] [-]
Simulium arcticum Moll. [-] [-] [LR72]
Simulium canadense Hearle [-] [-] [MR72]
Simulium decorum Walk. [-] [L472 [-]
Simulium furculatum (Shew.) [-] [GC72] [-]
Simulium sp. [5-71; 8-71; CC71; PR71; BR72; CC72; JC72; LC72] [L472] [HR71; JM71; MR71; TR71; HR72; JM72; LR72; PR72; TR72]
prob. Simulium sp. [CC72] [-] [-]
Simulium spp. [-] [-] [MR72]
Simulium tuberosum (Lundstroem) [5-71; CC71] [-] [HR71; MR71; TR71; MR72; TR72]
Simulium prob. tuberosum (Lundstroem) [45-71] [-] [-]
Simulium sp. venustum complex [-] [-] [MR71; TR71]
Simulium venustum Say [-] [-] [MR72]

(vi) Mycetphilidae [-] [L472] [-]

Allodia sp. [CC71] [-] [-]
Mycetophila sp. [CC71] [-] [-]
Mycomya sp. [23-71] [-] [-]

(vii) Empididae

Chelifera sp. [-] [-] [HR72]
Colabris ? sp. [-] [-] [MR72]
Drapetis sp. [-] [-] [MR72]
Hemerodromia rogatoris (Coq.) [-] [-] [MR72]
Hemerodromia sp. [CC72] [-] [MR72]
Hemerodromia sp. 1 [CC72] [-] [MR72; TR72]
Hemerodromia sp. 1A [-] [-] [MR72]
Hemerodromia sp. 2 [-] [EC72; GC72] [RR72]
Hemerodromia sp. 2A [-] [-] [MR72]
Hemerodromia sp. 3 [-] [-] [JM72; MR72; PR72; RR72]
Hemerodominae sp. 1 [7-71] [-] [HR71; TR71; MR72]
Hemerodrominae sp. 2 [42-71] [-] [HR71; TR71; MR72]
Hemerodrominae sp. 3 [-] [-] [HR71; MR71; TR71; MR72]
Hilara sp. [-] [-] [MR72]
Rhamphomyia sp. [CC72] [-] [-]
Roederiodes distincta Chill. [-] [-] [TR71; HR72; MR72]
Tachydromia n. sp. [CC72] [-] [-]
Tachydromia or Roederiodes [-] [-] [TR71]
Tachydromia? [-] [-] [MR71]
Wiedemannia sp. [CC72] [-] [TR71; HR72; MR72]

(viii) Ephydridae

Ditrichophora parilis Cress. [-] [MC71] [-]
Hydrellia sp. [-] [-] [MR72]
Ilythea spilota (Curt.) [-] [-] [MR71]
Metasyrphus perplexus (Osb.) [-] [-] [MR72]
Scatella stagnalis (Fall.) [-] [-] [MR71; MR72]

(ix) Miscellaneous

1. Psychodidae
   Psychoda sp. [-] [-] [MR72; RR72]
2. Dixidae
   Dixa sp. [8-71] [-] [RR72]
3 Sciaridae [BR72] [-] [MR72]
   Bradysia sp. [CC71] [-] [MR72]
   Lycoriella sp. [CC72] [-] [-]
   Phytosciara sp. [CC72] [-] [-]
4. Scatopsidae [CC72] [-] [MR72]
5. Cecidomyiidae [23-72] [-] [HR71; TR71; MR72; $\underline{=}$3 spp.; RR72]
   a) Lestrimiinae [-] [-] [MR72]
   b) Cecidomyiinae [-] [-] [MR72 $\pm$ 4 spp.]

b) (i) Porricondylini [-] [-] [MR72]
(ii) Cecidomyiini [-] [-] [MR72]
Lestodiplosis sp. [-] [-] [MR72]

6. Tabanidae
Chrysops sp. [-] [-] [MR71]
Chrysops ? ater Macq. [-] [-] [MR72]

7. Rhagionidae
Ptiolina sp. [CC72] [-] [-]

8. Dolichopodidae
Campsicnemus sp. [-] [L472] [-]

9. Sciomyzidae
Pherbellia sp. [-] [L472] [-]

10. Scatophagidae [-] [L472] [-]

11. Tachinidae [-] [L472] [-]

6. Acarina

Atractides sp. [-] [-] [HR71; MR71]
Calonyx sp. [-] [-] [HR71]
Lebertia sp. [5-71] [-] [HR71]
Trimalaconothrus glaber (Michael) [-] [-] [TR71]

7. Mollusca

Armiger crista (Linné) [-] [L771] [HR71]
Cyrtodaria kurriana Dunker [-] [BS13-72; BS14-72; BS18-72; BS19-72; KU72] [-]
Discus cronkhitei (Newcomb) [-] [WC71] [-]
Ferrisia rivularis (Say) [-] [-] [HR71; JM71; MR71; TR71; RR72]
Ferrisia sp. [-] [-] [JM71]
Gyraulis circumstriatus (Tryon) [3-71] [L571; L671; L771; CC72; EC72; GC72] [HR71; JM71; MR71; TR71; RR72]
Gyraulis deflectus (Say) [1-71] [L271; L471; L571; L771; CC72; C572] [-]
Gyraulis parvus (Say) [-] [CC72] [MR72; RR72]
Helesoma trivolvis (Say) [-] [L771] [-]
Lymnaea arctica Lea [-] [L671; CC72] [MR72]
Lymnaea atkaenis Dall [-] [EC71; L271; L471; L571; L771; L572; L1272] [-]
Lymnaea elodes (Say) [3-71] [EC71; L271; L471; L571; L771; CC72; L572] [HR71; MR71; TR71; RR72]
Lymnaea parva Lea [-] [-] [JM71]
Lymnaea stagnalis (Linne) [-] [L271; L471; L771] [RR72]
Physa gyrina Say [-] [L271; L471] [HR71; TR71; RR72]
Physa jennessi Dall [3-71; 58-71] [L571; L771; CC72; GC72] [HR71; TR71]
Pisidium compressum Prime [-] [L271; L471; LC472] [-]
Pisidium conventus Clessin [-] [L271; L1171; CC72; L372; SL172] [JM71]
Pisidium ferrugineum Prime [-] [CC72; SL172] [-]
Pisidium idahoense Roper [-] [EC71; L271; L471; L571; L671; L771; L1171; MC71; MC71; CC72; EC72; L472; L572; L772; L1272; LC472] [-]
Pisidium lilljeborgi Clesson [-] [L271; L1171; CC72; EC72; GC72; L472; L572; L1272; LC472; SL172] [RR72]
Pisidium milium Held [-] [L471; L771] [-]

Pisidium nitidum [-] [L572; SL172] [-]
Pisidium sp. [-] [L271; L471; L571; L671; L771; NC71] [-]
Pisidium subtruncatum Malm[-] [EC71; L271; L471; L571; MC71;CC72; EC72; GC72; L172; L372; L572; L772; L1172; LC472; SL172] [-]
Pisidium variable Prime [-] [L271] [-]
Pisidium ventricosum Prime [-] [L271; L471; L571; L771; CC72] [-]
Pisidium walkeri Sterki [-] [CC72; L172] [-]
Portlandia arctica prob. var. aestuariorum [-] [BS13-72; BS14-72; BS18-72; BS19-72] [-]
Probythinella lacustris (Baker) [-] [EC72; L172; L372] [MR71]
Promenetus exacuous (Say) [-] [L771] [-]
Sphaerium lacustre [-] [L471] [-]
Sphaerium nitidum Clessin [-] [L271; L471; L571; L671; L771; L1171; NC71; CC72; EC72; L372; L472; L572; L772; L1172] [-]
Sphaerium rhomboideum (Say) [-] [EC72; GC72] [-]
Succinea strigata Pfeiffer [-] [WC71] [-]
Valvata sincera Say [-] [L571; L671] [-]
Valvata sincera helicoidea Dall [BR71; 14-71; 16-71; 60-71] [EC71; L271; L471; L571; L671; L771; MC71; CC72; EC72; L472; L572; L772; L1172; MC72] [JM71; MR71; TR71]
Valvata tricarinata (Say) [3-71] [L271; L471; L571; L771; MC71; L472; LC472; [TR71]
Vertigo pygmaea Draparnaud [-] [GC72] [-]
Vitrina alaskana Dall [-] [-] [RR72]

APPENDIX VI

Stomach contents of some indigenous fish species from the Mackenzie Delta.

APPENDIX V1. Stomach Contents of some Indigenous Fish Species from the Mackenzie Delta.

Species	No. of Stomachs Examined	Location and Date	Food Consumed	% Total Number
Whitefish (*Coregonus sp.*)	182	Axial R. (Nov. 1971)	Gastropoda	8.74
			Pelecypoda	7.53
			Isopoda (*Saduria entomon*)	0.25
			Trichoptera	35.08
			Corixidae	3.10
			Coleoptera	0.19
			Chironomidae	0.55
			Ceratopogonidae	0.06
			Gasterosteidae	9.47
			Fish eggs	35.08
			Miscellaneous (app. 60% composition)	
Whitefish (*Coregonus sp.*)	69	Junction of Axial R. and East Channel (Dec.71-Jan.72)	Gastropoda	47.72
			Pelecypoda	5.01
			Trichoptera	44.33
			Plecoptera	0.44
			Corixidae	0.88
			Fish eggs	1.62
			Miscellaneous (app. 40% composition)	
Whitefish (*Coregonus sp.*)	25	Oniak Channel (Nov.18, 1971)	Isopoda (*Saduria entomon*)	3.66
			Mysidacea (*Neomysis Mercedis*)	1.22
			Fish eggs	95.12
			Miscellaneous (app. 70% composition)	
Inconnu (*Stenodus leucichthys nelma*)	2	Large lake connected to East Channel, 5 mi. SE of Tununuk point (Aug.1972)	Nematoda	11.11
			Isopoda (*Saduria entomon*)	18.52
			Chironomidae (Adults)	44.44
			Mysidacea (*Mysis relicta*)	18.52
			Lake Cisco juvenile (*Coregonus artedii*)	7.41
			Miscellaneous (app.40% composition)	

APPENDIX VI. Stomach Contents of some Indigenous Fish Species from the Mackenzie Delta. (continued)

Species	No. of Stomachs examined	Location and Date	Food Consumed	% Total Number
Arctic Grayling (*Thymallus arcticus*)	2	Large lake connected to East Channel, 5 mi. SE of Tununuk point (Aug. 1972)	Trichoptera (adults)	67.69
			(larvae)	4.23
			Miscellaneous Diptera (adults)	20.00
			Amphipoda (*Pontoporeia affinis*)	3.85
			Corixidae	2.69
			Acarina	0.38
			Ostracoda	0.77
			Miscellaneous (app. 60% composition)	
Lake trout (*Salvelinus namaycush*)	1	Large lake connected to East Channel, 5 mi. SE of Tununuk point (Aug. 1972)	Amphipoda (*Pontoporeia affinis*)	50
			Gastropoda	50
			Miscellaneous (app. 80% composition)	

APPENDIX VII

Field and laboratory methods utilized in Mackenzie-Porcupine watershed studies in 1971-72.

1. FIELD TECHNIQUES

1.1. Physical and Chemical Measurements and Sampling

Water and sediment samples and in situ measurements at selected stations were obtained by flying to the watershed in fixed-wing aircraft and helicopters, or by inflatable rubber boat, river scow, metal boat or canoe.

Temperature was measured with a battery operated YSI thermistor thermometer which could be read to 0.1°C. It was calibrated against a mercury thermometer and was accurate to at least 0.2°C.

Turbidity was measured with a 25 cm diameter Secchi disc (painted in black and white quadrants) mounted on a 1.5 m stick to which a meter stick was fixed. In turbid waters, reproducibility of this measurement was ±1cm; in clear waters, ±10cm. Turbidity was also estimated with a battery operated Hydroproducts Transmissometer. In turbid waters, where the light path had to be reduced to <5 cm, the reproducibility was ±5%T. Extinction coefficients were calculated from the Transmissometer data by the following formula:

$$k_{\alpha} = \ln \left[\frac{100}{\% T}\right] d^{-1}$$

where k_{α} is one estimate of horizontal extinction coefficient, %T is percentage transmission of light and d is the distance (meters) between the light source and photocell lens. This instrument was of limited use because of extreme turbidity in many localities.

Samples for analysis of elements in solution were taken with a plastic Van Dorn sampler, or in some cases by filling polyethylene bottles directly from the surface of the river. Samples for suspended sediments were collected with standard depth-integrating suspended sediment samplers (US-D-49, US-DH-59 and US-DH-48, see Inter-Agency Committee on Water Resources, 1963). Repeated depth profiles were made to obtain 2 liters of water, generally at maximum depth in the river cross section.

Bottom sediments were collected with Lane buckets, Ponar and Ekman Grab samplers as conditions allowed. Shore and bank sediments were hand sampled. Sediment samples were transported and stored at 4°C in sealed plastic sacks.

River flow was estimated with Gurley Model 625 Velocity meters, which were used to measure 2-10 profiles of velocity. Cross sectional area at the station was calculated from steel tape or by transit and rod estimates of width, and measurements of depth at the velocity profiles. For small streams the velocity meter was affixed to a metered wading rod, but in larger rivers the weighted meter was suspended by rope from an anchored boat. Precision was usually ±10% of stated values.

Conductivity was measured in situ with Beckman RB3 Solu Bridge Conductance Meters, calibrated against standard KCl solutions (APHA, 1971). Precision was ±10 µmhos/cm at 25°C. Seaward from the Mackenzie Delta, a Beckman RS5-3 Electrodeless Induction Salinometer was used, for which precision was estimated as ±0.2 °/oo

Water samples for O_2 determination were taken in 300 ml glass-stoppered bottles and transported to the field laboratory (Fort Simpson, Inuvik, Old Crow) for Winkler titration (APHA, 1971). Precision was ±0.1 mg l^{-1} or better. Unfiltered samples were used for pH and CO_2 system measurement: pH was measured with a

glass-calomel electrode pair and Radiometer PHM4 or PHM53 battery-operated meters. The electrodes were regularly calibrated against commercial buffers of pH 4-10, and precision was at least 0.05 pH units. These electrodes were used to follow the acid titration curve necessary for the measurement of HCO_3. Other species of the CO_2 system were then calculated from temperature, pH, and HCO_3 according to Garrels and Christ (1965).

Water samples for nutrient and trace element determination were filtered as soon as possible after collection, sometimes immediately, but in all cases within 8 hours. Samples were filtered through a Whatman GF/C filter held in a Swinnex filter holder affixed to a 50 ml plastic syringe in 1971-72. Due to difficulties in filtration by this method, we utilized a Falcon Plastics #7102 sterilized, all plastic, disposable filtration unit in 1972-73. One hundred and fifty ml or less was vacuum filtered through two of these units, using double filters (47 mm Sartorius SM1106 membrane of 0.45 μm pore diameter, and a pre-ignited Sartorius SM 13400 glass fiber pre-filter of 2 μm particle retentivity). Filtrates were acidified to pH 2-3 with high-purity HCl in especially cleaned polyethylene bottles. One filtrate was utilized for nutrient (total dissolved phosphorus [TDP], total dissolved nitrogen [TDN], dissolved silica [dSi]) determination in Yellowknife, and the other filtrate was analyzed for trace metals (Cu, Zn, Pb, Cd, Fe, Mn, As, Al) in Winnipeg. Additional samples of up to 20 L were taken for the measurement of suspended sediments. Filters in the filtration units were shipped to Yellowknife and Winnipeg for particulate C, N, and P measurement.

1.2. Zoobenthos Methods

1.2.1. General

Large river sampling technology has not advanced at the same pace as that of smaller fluviatile habitats. The Mackenzie River System poses many problems with respect to its benthos being adequately sampled. Current speeds are often in excess of 9km/hr, the bottom is composed of large gravel and boulders, often in continuous motion, and its width over most of its length is greater than one mile.

The beginning of this study in 1971 was a survey of the benthic fauna and an assessment of the relative abundances of the component organisms. In addition to quantitative sampling gear, attention was also paid to making the survey as qualitative as possible in this exploratory season by using miscellaneous collecting methods in each locality. The latter methods were invariably non-quantitative, but nevertheless allow a more complete picture of the faunal assemblages of this great river system to be recorded.

The quantitative sampling gear consisted, in many cases, of modified stream and lake sampling apparatus. Gear and methods were chosen with a view to their efficiency and repeatability over successive sampling seasons in the various habitats in which they were employed.

1.2.2. Collection of Benthic Organisms for Ecological Studies

Sampling technology differed between very large rivers (e.g. Mackenzie and Liard) and the small to medium sized ones (Harris, Martin, Driftwood). In general for the smaller rivers, one or two stations divided into riffle (fast) or pool (slow)

areas were used in 1971. Samples were taken in triplicate. In the Fort Simpson area at least two sites per river were used in 1972. The first site was close to the river's confluence with, but above the influence of the Mackenzie River; and the second about 1/2 to 1 km further upstream. Sampling sites were similar, usually located in a riffle or the lower end of a pool just above or below a riffle. In both Fort Simpson and the Yukon all samples were taken at 1/3 intervals across the stream or river channel. The very large rivers were sampled at fixed locations along their course either near the bank or in mid-channel.

The following equipment and/or techniques were used only in 1971.

1. Grabs

a) Ekman: Two models were used: one was 22.9 cm square, mounted on a handle, and the other a tall weighted version, 15 cm square, and messenger-operated. Both were used in localities with soft substrates.

b) Ponar: 22.9 cm square was used to sample the Mackenzie at Fort Providence, Fort Simpson, and certain localities in the Mackenzie Delta.

2. Nets

a) Kick: an equilateral triangular net of 405 μm Nitex, 30.5 cm to the side was mounted on a 153 cm handle. The net was put in a riffle and the area immediately upstream was disturbed by foot.

b) Dip: a 76 cm diameter hoop (405 μm Nitex net) was mounted in a 153 cm handle and was usually used in still areas. The bottom was stirred up with a handle and one meter sweeps were made with the net perpendicular to and just above bottom. It was also used as a trawl in large rivers.

c) Drift: An aperture of 30 x 45 cm was used with a 405 μm Nitex net. Metal loops on the side of the frame allowed the net to be staken perpendicular to substrate. They were usually set in smaller rivers and along the banks of very large rivers for varying lengths of time up to 24 hours. The top of the net broke the surface of the water so that allochthonous drift could be collected.

3. Standard Collection Time

All the benthos that could be hand-collected in 10 minutes; usually used in riffle areas where manageable-sized rocks were available.

4. Tow-Dredge - (Kolkwitz)

This is a dredge with a 30 x 10 cm gape and adjustable knife edges for varying substrate types. It was used to obtain qualitative epibenthic samples.

The following equipment and/or techniques were used both in 1971 and 1972:

1. Surber Sampler - (Surber, 1937)

1000 μm and 405 μm mesh net was used in 1971; 200 μm mesh in 1972. Substrate was sampled to a depth of 5-10 cm.

2. Artificial substrates

a) Periphyton sampler. A plexiglass slide, 2.5 x 7.5 cm was attached to the metal baskets described below. They were lifted monthly and put into a 'Whirlpak' bag in dilute formaldehyde.

b) Chicken tumble baskets as artificial substrates (Mason, et al. 1967). Cylindrical, 18 x 28 cm, wire baskets were filled with 25-30, 5-8 cm diameter rocks picked from locations at which the baskets were being installed. They were used in two ways: baskets were staked to the bottom of smaller rivers or to the banks of larger ones; and they were also suspended from a gang of polystyrene floats in deeper locations (Crowe, 1967). Six baskets composed one gang. In 1971, suspended baskets were hung at three different depths so the effect of depth on colonization could be studied. Baskets were removed approximately monthly. During removal, a dip net was placed under and downstream of the basket to catch invertebrates falling and jumping off. The rocks were cleaned with a paint brush and the resultant organic matter sieved and preserved.

3. Modified Ekman Grab

In the Mackenzie delta during 1971 the tall-weighted Ekman grab was used, whenever possible, as this is probably the best instrument for soft sediments (Flannagan, 1970). At deep stations with current speeds in excess of 3.7 km/hr and where compacted sediments occurred, either of the other two grabs were used. The Ponar grab is close to being an all-sediment sampler although it samples none exceptionally well (Flannagan, 1970) and the Petersen grab was used only as a last resort as it is a poor bottom-sampler, being less efficient than the Ponar (Powers and Robertson, 1967).

A modified Ekman grab was first used during winter 1971/72 and as it represented a considerable improvement over the former model, its use was continued through 1972. This grab was designed and built in the Freshwater Institute (Burton and Flannagan, 1973). It features a completely redesigned, spring-loaded messenger release which has a positive action and is less susceptible to jamming by ice or to misfirings. The body is free from internal projections and the jaws have strengthened springs. The lids are weighted and held open during descent, to be released at the same time as the jaws close. They then remain closed during ascent and prevent loss of organisms or sediment. The "cleaner" design of the grab allows a smoother descent and the "bow-wave" effect is minimized.

Mackenzie Delta channels were sampled at three sites across their width for each station. Three pooled grab samples were taken at each site, and also at lake and brackish-water bay stations.

4. Sled Dredge

In 1972, use was made of a sled dredge (Welch, 1948) to sample the Mackenzie River just above Fort Simpson. Also, a simple corer consisting of a 5.1 x 600 cm stainless steel pipe with a handle at the top end was used to sample the Harris River during the winter.

5. Treatment of Benthos Samples

Benthos samples were passed through a 200 μm mesh screen and sorted as soon as possible after collection. Sorting was accomplished with the aid of a 3x magnifying illuminator and binocular microscope.

6. Taxonomic Study Samples

In addition to the material provided by sampling techniques just described, several methods were used strictly for taxonomic purposes. In 1971, sweep nets were used to collect adults from grasses and bushes near sampling sites. Also, kick nets were used to collect immature Diptera larvae for rearing. Late instar Chironomidae larvae were placed in 2.5 x 6.4 cm vials. Sufficient water to just cover the animal was added and the vial was covered. Upon emergence, the adult, pupal skin, and last larval skin were removed and preserved in 70% ethyl alcohol and later were slide mounted for identification. In 1972, the rearing program was extended to include Ephemeroptera, Plecoptera, Trichoptera, and Tipulidae (Bjarnov and Thorup 1970; Entomological Research Institute, personal communication). Additionally, adults were collected by dishpans (Mundie, personal communication; dark green, plastic, 36 x 46 x 15 cm) filled with ethylene glycol. Four were placed along the bank at each station. The dishpans were emptied weekly by pouring the glycol through a sieve. The catch was preserved in 70% ethyl alcohol. In order to collect emerging adult insects and their cast skins, a Mundie drift-emergence sampler (Mundie, 1964 and 1966) was used. One drift-emergence sampler was placed at each station and was emptied weekly.

Simpler emergence traps were also used in several localities. These consisted of transparent plastic cones (0.1 m^2) which were either floated or submerged. Floating sticky traps (Mason and Sublette, 1971) were also used.

7. Life History Studies

The sampling frequencies in each locality are such that seasonal abundance and life history data are available in absolute terms (e.g. Surber and Ekman sampler - numbers of organisms and biomass/unit area) and in relative terms (e.g. artificial substrates - numbers and biomass/basket).

The benthos sampling methods used in 1971 and 1972 are sufficient to yield material for life history studies. The drift-emergence samplers and dishpans used in 1972 will give additional information regarding adult emergence times. Methods will follow Edmondson (1971).

8. Drift studies

The type of drift net used to examine the composition and diurnal fluctuation of organic drift was changed from the large net used in 1971 to a smaller one with a finer mesh in 1972. It measures 10 cm square with a 45 cm, 200 μm mesh net. Lateral rings and thumbscrews allow the net to be attached at any desired depth to two upright stakes in the river or stream being studied. In the Fort Simpson area three nets were placed at one-third intervals across each river, their tops being approximately one cm above the surface of the water so that allochthonous and autochthonous drift could be collected. A fourth net was placed approximately 2.5 cm above the substrate and under the middle surface net. The nets were cleared at two hour intervals over a twenty-four hour period. Clearing took five minutes per net and the contents of each net were preserved in 70% ethyl alcohol. During each drift sampling, water temperatures were taken when the nets were cleared and water samples for pH determination were taken every four hours. Drift studies were done in each river at monthly intervals. In winter, only the Martin River was studied. Two nets in the middle third of the river were used. Tents were erected above the sampling holes and heaters used to prevent the nets from freezing when

lifted. As during the open-water season, nets were cleared every two hours over a twenty-four hour period. Winter study frequency, however, was extended to every two months.

In the Yukon, Caribou Bar Creek Station CC1 was used for the study of drift patterns. A rectangular frame net was used which has a 30 cm opening and a 400 μm mesh size. Twenty-four hour benthic drift was sampled with net changing every hour. No replicates were taken.

1.3. Field Experimental Methods

We utilized two methods of experimenting with whole ecosystems. Firstly, we selected a locality for regulated addition of crude oil to a stream and a lake which could be compared to a control locality. Secondly, we utilized natural occurrences of oil or silt addition to ecosystems for which we had background data and control areas. These methods are described below.

1.3.1. Caribou Bar Creek Oil Spill Experiment

Prior to August 16, 1972, three sampling stations were established on each of the two tributaries, and five others on the main channel. Each station was sampled for benthos using Surber Samplers. Three samples were collected at each site. The biota was identified and enumerated. Banks of slides were installed as periphyton settling surfaces.

During a 24 hour period one week preceding the oil spill, benthic drift was measured at the three tributary stations. At the lower portion of the experimental tributary one floating barrier was erected to contain and facilitate the removal of oil. Downstream from this a sphagnum barrier was located across a riffle to collect any oil residue. Two hundred and fifty liters of Normal Wells crude oil was pumped on to the creek at 1430 hr., 16 August, 1972.

Surber samples were collected on the day following the spill, a week later, and bi-weekly afterwards. These samples were compared to associations and quantities of benthos present in the control stream, and in the portion of the stream's bed not covered by oil. Periphyton slides were also collected at pre-determined intervals.

1.3.2. Mackenzie Delta Lake Oil Spill Experiment

At 1633 MST, 5 August, 1972, 409 liters of Normal Wells crude oil was pumped onto a small Delta lake (L.4). The pumping operation took one hour and the whole sequence of pumping and the subsequent dispersal of the oil over the lake surface was photographed from the air. Prior to the spill the profundal benthos was sampled along a north-south transect using methods previously described in section (5.1.2.). In addition, the littoral benthos of an experimental "plot" at the NW end of the lake was sampled using a 200 μm mesh, triangular dip-net. This NW area of the lake was that initially affected by heavy concentrations of the spilt oil. The "plot" measures 1.8m x 0.30m and was sampled in two ways. The oil/water interface was sampled to a depth of 0.3m using the net and then the underlying mud-vegetation interface was swept

by the same net six times.

To remove as much oil as possible, the samples were immediately removed to the lab and washed; then they were sorted. Great care had to be taken in sorting as the oil complicated the normal picking procedure. Samples were again sorted using a 3x illuminated magnifier and binocular microscope with frequent intermediate washings.

Primary productivity of phytoplankton was estimated prior to and following the spill using the C^{14} method (Hanna, unpublished). Macrophytes from the whole lake bottom and margin were collected only prior to the spill.

Microorganism population sampling of Lake L.4 in the Mackenzie Delta was initiated in March and bacterial samplings of this lake and LC4 were taken at intervals during the year. These will be continued in the coming year. Two litre water samples were taken aseptically from one and two meter depths with a Niskin bag sampler. Surface mud samples were withdrawn aseptically from an Ekman grab by means of a modified three ml disposable syringe. All samples were chilled while being transported to laboratory facilities in Inuvik, and the processing of samples began within three hours of collection. In processing water samples, aliquots of various sizes were filtered through 0.45 μm cellulose acetate filters (47 mm diameter) (Millipore Corp.). A one ml portion of wet mud was added to 100 ml of sterile lake water, shaken vigorously, and serially diluted. Aliquots of several dilutions were then treated in the same manner as water samples. After filtering, filters were placed on nutrient pads which had been previously moistened with two ml of Tryptic Soy broth (Difco) in Millipore petri dishes. All samples and materials were chilled up to this point with crushed ice. Triplicate sets of dishes were incubated at 5° and 15°C, both aerobically and anaerobically, and colonies of cells developed on the filters within one to two weeks. After two weeks, colonies on all plates were enumerated.

From each sampling of the lakes, a representative proportion of colonies grown on the plates were purified and tested for various parameters. These include: morphology; motility; pigment production; growth at 5°, 15°, 20°, and 30°C; anaerobic growth; sodium requirement; nitrate reduction; hydrogen sulphide production; qualitative assays for oxidase, catalase, hemolysin, proteinase, amylase, chitinase, and lipase. All isolates were routinely screened for ability to utilize Norman Wells crude oil as a sole source of carbon. Ten ml liquid cultures with 0.1 ml of sterile oil were agitated at 250 rpm at a temperature of 15°C for five days. At the end of that time, the loss of oil and formation of biomass was determined visually.

1.3.3 Yellowknife Bay Oil Spill

In July 1972, a heavy oil appeared on Yellowknife Bay near Yellowknife. Fisheries Service personnel investigated the slick and found that its source was the Con-Rycon dock area. After consultation with Fisheries Service Officers, we began a brief sampling program to ascertain the effect of this heavy (similar to crude) oil.

On July 26, 1972, three Burton Ekman samples were collected from 1) a shallow bay (0.5 m depth) where the oil had been collecting; 2) a point immediately below the oil source (2.0 m depth); and 3) a point 4.75 m depth in the vicinity of the spill. Replicates for these were collected at similar sites across

the bay, which may not have been exposed to the oil. The organisms were sorted and counted, and the results were tabulated in terms of standing crop and taxonomic composition. Emergent vegetation was also hand sampled and the area was photographed.

1.3.4. Substrate Colonization Studies

As part of our program to assess the effects of crude oil on benthic flora and fauna, artificial substrates (Mason et al, 1967, - see 1.2.2.) coated with Norman Wells crude oil were placed in several localities within each region.

In the Fort Simpson region they were placed in the Trail (low turbidity) and the Liard (high turbidity) Rivers. In the Yukon, artificial substrates were placed in Caribou Bar Creek (low turbidity) and in the Mackenzie Delta they were used in the turbid waters of the East Channel. Physical and chemical data for these localities are given in Appendix IX, X and XI.

Plexiglas slides and chicken barbeque tumble baskets filled with rocks were the artificial substrates used to collect benthic flora and fauna respectively. The plexiglas slide was attached to the basket and the basket was rotated twice in a dishpan of oil, lifted out and the excess oil allowed to drain. A rock was then removed for quantitative oil analysis (see Chemical Methods Section, 2.2.) and the basket placed in the river. Artificial substrates were fixed to the bottom in the Trail and suspended from floating gangs in the Liard. Untreated substrates were used upstream of the treated as controls. The substrates were subsampled for quantitative oil analysis.

In Caribou Bar Creek, YT, six artificial substrates were set above the spill area as spill controls, staked to the substrate. In addition, 6 were set in the control creek. In the experimental section, six non-dipped artificial substrates were set prior to the spill. These latter ones received oil only from our man-made spill. Another set of six artificial substrates were directly dipped into a barrel of crude oil and staked to the bed of the experimental section of the stream. Sets of three artificial substrates were removed from each locality after one month; the rest will be removed in Spring, 1973.

In the East Channel of the Mackenzie, three gangs of suspended artificial substrates were set at Station EC10 near Inuvik in July 1972. Each gang consisted of six artificial substrates, three of which were oil-dipped and the remaining three were unoiled. Setting and dipping were as described above. One gang was removed one month after setting and a second, two months after setting. Another gang was set in mid November through ice, and was removed in mid December. Gang-removal was carried out as previously described.

1.3.5. Oil Sampling and Shipping

In the Caribou Bar Creek Oil Spill Experiment, samples of the stream sediment were taken with a small core tube of sampling area 78.5 cm^2. These samples were placed in a plastic "Whirlpak" bag and sealed for shipment. This device was also used in the littoral zone of the Lake 4 (Mackenzie Delta) Oil Spill Experiment. Samples of water for oil measurement were taken in pyrex glass stoppered O_2 bottles, or in some cases 2 litre polyethylene bottles. Oiled and non-oiled stones in artificial substrate baskets were put into Whirlpaks before installation and after recovery of the basket.

We now realize that these sampling and shipping methods were not satisfactory and improvements were made for 1973-74.

1.3.6. Mudslide on Caribou Bar Creek

Sometime between August 13 and August 15, 1972, a mud slide occurred on the western bank of Caribou Bar Creek, approximately 10 m long, by 5 m wide, and 1 m deep. The net result was an increase in suspended sediments in the lower portion of Caribou Bar Creek.

Three Surber samples were collected on August 15th, directly above and below the mud slide, and 275 m below it. The sampling was repeated on August 31 and September 14. At the latter date the slide appeared to be stabilizing, probably due to freezing.

1.3.7. Fort Simpson Highway Impact Studies.

One sampling station had already been established on the Martin in 1971 just above its confluence with the Mackenzie (see Fig. 7d, App. 1) as part of the Mackenzie mainstem baseline ecology survey. In early June, 1972, the 1971 site was replaced by two other stations established further upstream (see App. I, Fig. 7d). According to the best advice available at the time concerning the Mackenzie Highway routing, a third station, meant to be upstream of the highway crossing, was established further upstream four days later (see App. I, Fig. 7d). An 8 m wide survey slash crossed the Martin in early July about 11 km upstream from its confluence with the Mackenzie and about 5 km further upstream than our furthest upstream station. The first bulldozer crossed the Martin on July 13, 1972. We established two more stations - upstream and downstream of the crossing - on July 19 - 21, 1972 (see App. I, Fig. 7d). Figs. 16 and 17, text, show the narrow slash and riffle area used by tracked vehicles for crossing the river. A bank slide on the west bank became evident by mid-August. Widening of the right of way to 30 m was completed by mid-September, 1972 and by September 19, 1972, the slump had increased in magnitude. By November 10, 1972, a second set of approaches had been cleared and a winter road had been put across the Martin about 0.4 km downstream from the first crossing. This second crossing is slated to be the site of a temporary bridge. Another station was added downstream of the crossing at the end of November.

To March, 1973, there had been three open-water sampling trips (July 19-21; August 16-18; and September 13-15, 1972) and one winter trip (November 28-30, 1972) to the stations at the highway crossing and further downstream on the Martin for highway impact studies.

Benthos samples were taken on a monthly basis. The boulder substrate of the Martin River necessitated the use of artificial substrates for benthos sampling. Baskets were placed in pools in each of the six stations on the river. Enough were installed to allow three to be removed, in a transect across each station, at each sampling date. Suspended sediment samples were taken at upstream and downstream ends of the pools of the three crossing site stations in an attempt to detect silt deposition in the pools. Areas suitable for Surber samples were found upstream and downstream from the crossing site. Three Surber samples were taken in a transect across each suitable area at each sampling date. Downstream drift, of benthic invertebrates, an important parameter of benthic life in running waters, has been shown to be sensitive

to stream disturbance. Therefore, 24-hour drift studies were done on each sampling date. Drift studies were done at Stations A (upstream of disturbance), B (downstream of disturbance) and 3 (farther downstream of disturbance) on July and August, and at A and B only on September and November sampling dates. The recommended method of studying drift is to pass the entire flow of water through a driftnet. In large rivers or streams this is not possible. This was the case with Fort Simpson rivers and so a number of nets were placed in lateral and vertical transects so that estimates could be made of the differences in drift from side to side and top to bottom in the water column. The following design was used:

Three 10 x 10 x 45 cm nets using 200 μm Nitex were placed in a transect across the station, the top of each one breaking the water surface so that allochthonous as well as autochthonous drift could be collected. A fourth net was placed under the middle net a few cm above the substrate. Nets were cleared every two hours. Water velocities were measured at the mouth of each net at the start of the drift study, halfway through, and at the end. Temperatures were taken every two hours and water samples for pH determination every four hours, both coincident with the period of net clearing.

During the August and September, 1972 sampling trips, opportunities arose to study the effects on drift patterns of tracked vehicles crossing the Martin River. A planned crossing of the Martin River by a Nodwell substrate coring unit, a tracked vehicle weighing approximately 6350 kg, on August 18, 1972 enabled a study of the effects of such a crossing on patterns of invertebrate drift. Nets were placed as described above. They were cleared every two hours. Because of the unpredictability of the exact crossing time, no pre-crossing nets could be run. However, this data was extracted from the previous day's drift samples.

Full descriptions of the equipment used for physical, chemical, and benthic sampling are given in Section 1.1. and 1.2.

The effect of two culverts (at the Fort Simpson - Fort Nelson highway crossing) in the Poplar River system was studied. Single 10 x 10 x 45 cm drift-nets with 200 μm mesh Nitex were placed in rocky, fast water areas in mid-channel, well above the upstream disturbed area, and just downstream of the outfall pool. The nets were cleared every two hours over a four-hour sampling period.

2. LABORATORY METHODS

2.1. Yellowknife Laboratory

Measurement of pH, HCO_3 and conductivity was done on unfiltered samples. Conductivity was measured with a Radiometer CDM2e line operated unit. Reproducibility and limits of detection for all parameters and constituents measured in the Yellowknife and Winnipeg laboratories are cited in Appendix VIIIA.

Silicate was measured by the method of Armstrong and Butler (1962). Total dissolved nitrogen (TDN) and total dissolved phosphorous (TDP) measurements were made by the methods of Wood et al. (1967) and Murphy and Riley (1962) respectively, after UV photochemical combustion (Armstrong and Tibbitts, 1968). A spectrophotometer with a flow-through, 1 cm cell and digital printer was used for these determinations. Analyses for chloride and sulfate were carried

out using the ion-exchange procedure of Mackereth (1955). Arsenic in solution was measured by the colorimetric molybdate method of Johnson (1971) for the simultaneous determination of arsenate and phosphate. In this procedure, arsenate concentration is determined by taking the difference in absorbance between a reduced and an unreduced sample. Particulate phosphorous (PP) and arsenic (PAs) were occasionally determined by this method after ignition of the filter or sediment at 500°C for 1 hour and bringing the ash into solution with dilute HCl.

The weight of suspended sediment was determined by centrifuging 2 - 20 l. water samples in a Sorval RC2B centrifuge with a continuous flow unit. The collected sediment was carefully dried at 110°C in the centrifuge tube, weighed, ground with mortar and pestle, and transported to Winnipeg in plastic vials for mineralogical and chemical analyses. For waters of low amounts of suspended material (<25 mg l^{-1}), samples were passed through pre-ignited, pre-weighed Whatman GF/C filters, and suspended matter estimated by gravimetry (APHA, 1971).

2.2. Winnipeg Laboratory

The major cations (Ca^{++}, Mg^{++}, Na^{+}, K^{+}), and manganese and iron were determined directly without preconcentration of the water sample (dilutions with distilled, demineralized water were made when necessary) by conventional flame atomic absorption spectroscopy (Perkin Elmer, Model 403). Machine settings and the analytical methods were those given in the Perkin Elmer Methods manual "Analytical Methods for Atomic Absorption, March 1971".

The metals Cu, Zn, Cd, Pb, Fe, were determined by the graphite tube flameless atomic absorption method using an HGA 70 Perkin Elmer graphite cell unit and a 403 Perkin Elmer spectrophotometer. Analytical sample volumes of 50 µl, injected with an Eppendorf pipette, were used, and the instrument was calibrated against synthetic standard solutions prepared daily from 1,000 mg/l stock solutions. The high sensitivity and very low detection limits attainable with this method for a number of metals made it possible to determine metal concentrations in natural water samples at the sub-micro mole/l concentration level directly without prior concentration of the sample solution. The basic principles and operational techniques of the graphite tube analytical method were described in detail by Massman (1968), and Manning and Fernandez (1970). Articles by Paus (1971) and Kahn (1971) deal with application of this method to analysis of trace metals in natural water.

Precision estimates comprising sampling and analytical errors were established for all chemical determinations (Appendix VIII, Table A). Since precision is generally a function of concentration and the latter varies in natural waters with time over a range of values for most chemical species, it is more realistic to give a precision range (in terms of the coefficient of variation) rather than a single precision estimate: 2-3% for Na^{+} and K^{+}; 4-7% for Ca^{++}; 1.2-8% for Mg^{++}; 1-2% for Si; 7-26% for TDN; 17-40% for TDP; 4-37% for Fe; 5-13% for Cu; 2-15% for Pb; 0.5-22% for Cd; 1.7-32% for Zn; 2-5% for Cl^{-} and 3-18% for SO_4^{--}. In general, precisions are good for concentration levels substantially higher than the detection limit of the analytical method (optimum concentration level) but get progressively worse as the concentration level approaches the limit of detection. More pertinent are the tabulated precision data in Appendix VIIIB, which indicate actual variation in field sampling and analyses, the effect of transport time, and variation in 6 replicates of analyses in Yellowknife and Winnipeg laboratories. Clearly, our greatest source of error in some cases is sampling and transportation time of the sample.

Particle size composition of bottom sediments in terms of fraction of sand (2000-50 μm), fraction larger than sand (2000 μm and larger), fraction of silt (50-2 μm), and fraction of clay (2 μm and smaller), was determined by the pipette method of Jenning (1922) and Robinson (1922). In a few instances the more refined centrifugation and settling method of Jackson (1956) was used. Minerals were identified in fractionated and unfactionated sediments by X-ray diffraction (Klug and Alexander, 1954) with a Phillips diffractiometer (PW 1010 Generator, PW 1352/10 Circuit Panel, PW 1170/00 Automatic Sample Holder, AMR-3-202 Graphite Monochromator, Fe filtered, Co radiation). Major metals in sediments were determined by X-ray fluorescence spectroscopy (Wilson et al. 1965), with a multi-channel ARL X-ray spectrometer. Sediment samples were also fused with lithium tetraborate and dissolved in 1N HCl for flame atomic absorption determinations. Total carbon and nitrogen in bottom sediments were determined on dried (110^{o}C), ground and well-mixed sediment samples with a Carlo Erba Model 1100 CHN-analyzer. Suspended sediments that were collected by filtration on glass fiber filters (preignited at 525^{o}C for 16 hours) were analyzed for carbon and nitrogen with modified Carlo Erba, Model 1102 and Perkin Elmer, Model 240 CHN-analyzer instruments. The modifications to the instruments consisted of changing the sample introduction mechanism to accommodate a whole glass fiber filter with particulate matter, allowing for analysis of a whole filter plus sample in one operation. Inorganic carbon in sediments (Calcite, dolomite) was determined as follows (Stainton, unpublished): a weighed quantity of dried ground sediment (or a glass filter with particulate matter) and the appropriate quantity of sulfuric acid were introduced into a glass ampoule which was then sealed quickly and autoclaved at 121^{o}C for one hour. The liberated CO_2 was analyzed by gas chromatography. Total phosphorus in sediments or in particulate matter collected on glass fiber filters was routinesly analyzed according to Stainton (unpublished). Glass fiber filters with the collected particulate matter (or a quantity of sediment) were inserted into a glas vial which was then heated in a muffle furnace for one hour at 550^{o}C to destroy organic matter and to oxidize the sample. After cooling, dilute hydrochloric acid was added and the sample was digested for two hours at 104^{o}C to hydrolyze phosphorus compounds to orthophosphate. Reagents were added to the cooled vial, and orthophosphate was determined without transfer of solution by the method of Murphy and Riley (1962).

Considerable methods research was done for this study, as we realized that 1) sampling at remote localities under less than ideal laboratory conditions, 2) transportation and storage time 3) the suitability of various preservatives, and 4) filtration errors, would greatly affect our analytical results. We included two reports on some of this research in Appendix VIII C and VIII D. They indicate that trace elements "in solution" are greatly determined by the pore size, composition, commercial source of the filters, and that some commercially available filters are significant sources of contamination to the filtrate and to the material caught on the filter. These manuscripts of Appendices VIII C and D are draft copies that will be further revised for publication elsewhere.

The measurement of small amounts of oil in sediments and water samples caused us some difficulty. For stones used in the artificial substrate wire baskets, pesticide grade hexane was added to the Whirlpak, and the solvent, stone, and oil was poured into a beaker. The plastic sack was repeatedly rinsed with hexane, and the rinse added to the beaker. The extract was brought to constant volume,

and an aliquot was taken for absorbance measurements at 1968 Å (deuterium lamp) with a Cary 14 or Unicam spectrophotometer. Standards were made by adding 0.5-10 ml of Norman Wells Crude Oil (the same batch as used in the field experiments) to hexane. Blank values were determined from hexane extracts of oil-free plastic sacks, or samples taken from control areas in plastic sacks.

Sediment samples (silt, sands, organic-matter rich muds) were extracted with pesticide grade hexane in a soxhlet apparatus for 12-16 hours. The extract was treated as described above (Am. Soc. Testing and Materials, 1966). Estimates of precision and sensitivity are lacking at the present.

2.3. Benthos Laboratory Methods

Samples which had been screened using a 200 µm sieve were sorted at the field camps, preserved in 70-80% ethanol and then shipped to the benthos laboratory in Winnipeg in allergy vials with rubber stoppers. These samples were accompanied by preliminary data sheets.

At the Winnipeg laboratory the samples were checked, and selected vials were prepared for shipment to experts for identification purposes. Some specimens (e.g. adult chironomids, reared insects and obligochaetes) were further prepared by being mounted on microscope slides prior to identification.

The Winnipeg laboratory is also responsible for receiving returned identified specimens, collating and tabulating the data from all sources and establishing a reference collection of benthic invertebrates from the study area.

3. DATA ANALYSES

3.1. Chemical Data

Daily discharge data for the Mackenzie and Porcupine Rivers and a number of its tributaties were obtained from our more crude estimates and the better quality data of Water Survey of Canada. Water Survey data were grouped into consecutive 7-day periods (commencing January 1) to obtain estimates of mean weekly discharge. In calculating discharge of the Mackenzie River above Liard River (the Water Survey station was below the Liard River) an additional step was necessary; mean weekly discharge was estimated by subtracting the sum of the mean weekly discharges of the South Nahanni River at Clausen Creek and the Liard River at Fort Liard from the mean weekly discharge obtained on the Mackenzie below the Liard River. This manipulation was not necessary in 72-73 as another station was installed at the mouth of the Liard River.

By grouping mean weekly discharges, a value was subsequently obtained for mean monthly discharge (m^3 sec^{-1}). For months when no discharge data were available, for example during peak runoff in the spring, estimates were made based on average values from previous years' data from Water Survey. Total monthly discharges were summed to obtain an estimate of annual discharge.

Rates of transport were calculated for the following parameters: total suspended sediment (SS), dissolved Ca, dissolved Mg, dissolved Na, dissolved K, dissolved SO_4, dissolved Cl, dissolved Si, dissolved HCO_3, particulate C (PC), particulate N (PN), dissolved N (TDN), total N (ΣN), particulate P (PP), dissolved P (TDP) and total P (ΣP). To correspond with the frequency of sampling

in the field, monthly transport rates were estimated. For a particular component, the rate was obtained by multiplying the analytically obtained concentration times the total monthly discharge. During 1971, for months when no analyses were available, concentration means were applied; for a given river station, these mean concentrations were the "average" of all the concentration values obtained there. Annual rates of transport were estimated by summing the monthly rates.

3.2. Biological Data

The density of benthic organisms collected by any of the various grab or Surber samplers may be expressed in terms of numbers per unit area or as percentage occurrence. For artificial substrate samples, the quantity is a relative one: numbers per basket. With the use of appropriate wet or dry weight conversion factors it will be possible to relate benthos densities to biomass per unit area.

We are identifying benthic organisms to the lowest possible taxon, but with such a large number of species and samples we can only speak of taxon abundance above the species level in the majority of cases at present.

The relationship between benthos density and distribution, and selected physical and chemical parameters is being established, utilizing the physical and chemical data collected concurrently with the biological samples.

The diversity of benthic components within each system will be assessed using an expression similar to the Shannon-Weaver index:

$$H'' = -\Sigma \frac{n_i}{N} \log_e \frac{n_i}{N}$$

Where n_i = no. of species to *i*th sp.
N = total no. of species

The final goal is to derive a predictive model relating benthos to the selected physical and chemical parameters which are likely to be affected by watershed disturbances, similar to the treatment used by Green (1971).

APPENDIX VIII

Estimates of precision and semsitivity of the physical and chemical methods used in Mackenzie-Porcupine watershed studies, and some results of research on the use of filters in this study.

APPENDIX VIII A

Precision and sensitivity of chemical methods

Chemical instrumentation and analytical methodology change with time. Consequently, accuracy and precision of chemical data change with time. Utilization of chemical data by future investigators and unambiguous interpretation depend crucially on knowledge of analytical precision and reliability of data. It is therefore deemed essential ti give precision estimates for chemical data whenever possible, especially when the data are baseline data intended for long-term use. What follow are precision estimates for chemical determinations by the various analytical methods used in this investigation.

DISCUSSION

Precision estimates in Tables I and II are based on chemical data for lake water. These data were obtained with the same instrumentation and analytical methods as the data in the present investigation. It was shown using Liard River water ("Liard River Total Precision Test", Appendix VIII B, this Report) that these precision estimates are equally valid for river water.

Flame atomic absorption and spectrophotometry:

In Tables I and II the coefficients of variation in column 1 were calculated from six determinations of the same bulk water sample, and in column 2 from six determinations of six separately collected water samples. In column 3 precisions were calculated from thirty-three average concentration values each of which was obtained for a monthly depth-concentration profile of Lake 305 in the Experimental Lakes Area, 35 miles east-southeast of Kenora, Ontario, Canada. The important sources of error which determine precision of column 1 are instrumental variation, sample inhomogeneity, human random error and variation in laboratory operations. Precision of column 2 is determined in addition to the errors cited by sampling errors, and of column 3 by long-term variation in instrument response, change in instrument operator and change in conditions and chemical procedure not compensated for by similar changes in standards.

X-ray fluorescence and flameless atomic absorption:

In Table III standard deviations in column 1 were calculated from ten replicate analyses of the same sample disc (K. Ramlal, University of Manitoba) and in column 2 from ten analyses of ten different sample discs (all SY-1 standard rock sample) individually fused. Since standard deviations in column 2 were calculated with reference to an accurately known composition (Certificate Values), and not by an average of experimentally obtained values, it is reasonable to speak of accuracy rather than precision in this case.

In Table IV the analytical precision was calculated from ten to twelve repetitive analyses of the same bulk sample of river water. The analyses were performed under routine operation conditions.

Table I. Analytical precisions for flame atomic absorption - (Perkin Elmer Model 403)

Component Analyzed	Concentration level millimoles/1	1 Only laboratory random errors contribute: Coefficient of variation % ($\frac{\sigma}{\bar{x}}$ x 100 **)	2 Laboratory and field sampling errors contribute: Coefficient of variation %	3 Laboratory and field sampling errors contribute plus long-term variations: Coefficient of variation %	Detection limit millimoles/1
Na	.087-1.260	1.1-1.2	1.8-2.5	9.3 (0.04)*	0.0022
K	0.010-0.102	1.0-3.3	2.6-2.9	5.0 (0.01)	0.0013
Mg	0.029-1.646	3.5-1.2	7.9-1.2	2.8 (0.03)	0.0021
Ca	0.050-1.500	3.1-2.2	6.9-3.8	10.0 (0.05)	0.0013

* numbers in brackets are concentration levels in millimoles/1

** σ is the standard deviation and $\bar{x}$ is the average concentration

Table II. Analytical precisions for spectrophotometry (Bauch and Lomb Spectronic 400)

Component Analyzed	Concentration level micromoles/1	1 Only laboratory random errors contribute: Coefficient of variation % ($\frac{\sigma}{\bar{x}}$ x 100 **)	2 Laboratory and field sampling errors contribute: Coefficient of variation %	3 Laboratory and field sampling errors contribute plus long-term variations: Coefficient of variation %	Detection limit micromoles/1
P (TDP)	0.29-6.4	34-10	40-17	14 (0.23)*	0.16
N (TDN)	32-94	5.0-8.2	6.9-26	25 (12)	0.71
Si	170-230	1.6-1.3	1.9-1.8	4.2 (35)	.036

* numbers in brackets are concentration levels in micromoles/1

** σ is the standard deviation and $\bar{x}$ is the average concentration

Table III. Analytical precisions for X-ray fluorescence (Multichannel ARL X-ray Spectrometer)

Component Analyzed	Concentration level millimoles/gm.	1 Instrument precision standard deviation millimoles/gm.	2 Accuracy of replicates standard deviation millimoles/gm.	Detection limit millimoles/gm.
Si	10.0	0.020	0.033	0.832
Al	1.77	0.010	0.025	0.196
Fe	1.25	0.0021	0.0038	0.063
Mg	0.992	0.0099	0.0248	
Ca	1.78	0.0035	0.0125	0.089
K	0.552	0.0021	0.0021	0.0021
Mn	0.0578	0.0014	0.0014	0.0014
Ti	0.090	0.0025	0.0025	0.0125

Table IV. Analytical precisions for graphite tube flameless atomic absorption (Perkin Elmer HGA70)

Component Analyzed	Wave length Å	Concentration level micromoles/l	Instrumental precision** Coefficient of variation%	Detection limit micromoles/l	Absolute detection limit moles	Sensitivity* moles to give 1% absorption
Fe	2483.3	0.0896	37	9.0×10^{-2}	3.6×10^{-13}	9.0×10^{-13}
		0.179	16			
		0.538	11			
		0.896	3.8			
Cu	3247.5	0.0394	13	3.9×10^{-2}	1.9×10^{-13}	1.1×10^{-12}
		0.0787	6.9			
		0.158	6.3			
		0.394	5.2			
Pb	2833.1	0.0048	14	4.8×10^{-3}	4.8×10^{-13}	2.4×10^{-12}
		0.0241	15			
		0.145	5.6			
		0.241	4.5			
		0.579	2.7			
		0.724	1.8			
Zn	2138.6	0.0153	32	1.5×10^{-2}	1.5×10^{-14}	3.1×10^{-14}
		0.0765	18			
		0.153	3.6			
		0.306	5.7			
		0.459	1.7			
Cd	2288.0	0.0089	22	8.9×10^{-3}	9.0×10^{-15}	2.7×10^{-14}
		0.0445	11			
		0.0890	15			
		0.178	2.9			
		0.267	0.8			

Table IVcontinued

Al	3092.7	0.185	20	1.9×10^{-1}	7.4×10^{-12}	7.4×10^{-12}
		0.370	15			
		1.11	10			
		1.85	6.5			
		2.96	4.3			

** Based on 10 to 12 determinations for each different concentration level

* Data from Perkin Elmer methods manual for "H Ga70" unit

APPENDIX VIII B

LIARD RIVER TOTAL PRECISION TEST

R. Wagemann

INTRODUCTION

The purpose of this investigation was to obtain realistic overall error estimates for the various chemical measurements under actual conditions of operation, and to discover some of the important factors which may contribute systematic and random errors. The factors that were considered are acidification vs. nonacidification of filtrate, filtration with two different brands of glass filter and two different filtration units, filtration by three different laboratories, and analysis of repeatedly (or multiply) collected samples vs. repeated analysis of one (or singly) collected sample.

Due to analytical requirements it was not possible to test all the factors mentioned for each type of analysis. For example, in using the hydrogen ion exchange method (followed by conductance measurement) of Mackereth (1955) for sulfate and chloride determination, sample acidification prior to analysis is precluded on analytical grounds. These determinations were therefore made only on unacidified filtrates or centrifugates. The nutrients (TDP, TDN) were determined on acidified filtrates only. It has been well substantiated in the past that in unacidified or otherwise unpreserved water samples these constituents change drastically in a matter of a few days (Jenkins, 1968; Henriksen, 1969). Because the minimum time lapse between collection and analysis could not be reduced to less than five days due to transportation difficulties and the remoteness of the area, and the samples could not be frozen, there was no point in analysing unacidified filtrates for nutrients for the purpose of this investigation.

DISCUSSION

The overall precision of chemical determinations under conditions of this program as established by this investigation (Table V) is in general very comparable to overall precisions previously established under different conditions in connection with other programs (Wagemann and Stainton, in prep.). Anomalously large errors in a few isolated instances were found for sodium (22%), magnesium (15%), chloride (113 to 120%), and TDP (105%), but such large inaccurracies were few and spurious and therefore are considered unrepresentative. For this reason these values are not included in Table V.

No significant difference in precision was found for multiply collected samples and singly collected sample for all but the following determinatinations: TDP, Fe, SO_4, PN, PC. These determinations were all less precise for multiply collected samples than for the singly collected sample, which indicates that the method of sample collection had some adverse effect on precision for these determinations but not for others.

A comparison of determinations for two different brands of glass fibre filters, wherever this is possible, (using two different filtration units) shows that only sodium, iron and PP, PN, PC determinations are affected by filter or filtration unit. The average sodium ion concentration in filtrates obtained with the Falcon plastic filtration unit using a Sartorius glass filter was substantially higher in all cases than in filtrates obtained with the Millipore filtration unit using a Whatman glass filter (Tables 1,2); this in turn was higher than in centrifugates. Subsequently it was established that this increase in Na concentration was due chiefly to difference

in brands of glass filter and possibly due to differences in treatment of glass filters (Table IV), and only marginally if at all due to difference in filtration apparatus. The observation that glass filters introduce sodium ion contamination is in accord with results of previous work (Wagemann and Graham, Appendix VIII D). Higher average values of phosphorus, nitrogen and carbon in particulate matter were obtained when particulate matter was collected on Sartorius glass filters with the plastic filtration unit, than when collected on Whatman GF/C glass filters with the Millipore filtration unit (Table III). A number of explanations could account for this difference: 1) Whatman glass filters retained more particulate matter than Sartorius filters because of some difference in retentivity of filters; 2) filtration with the plastic unit allowed some particulate matter to bypass and not be retained by the Sartorius filter. The latter explanation has merit but is not borne out when seston weights obtained with the plastic filtration unit and the Millipore filtration unit are compared. The difference in concentrations of iron in filtrates obtained with the plastic filter unit and the Millipore filter unit is very probably due to the different filters used in these two units. A double filter system, a Sartorius glass filter superimposed on a Sartorius, 0.45 μm membrane filter (cellulose acetate) was used with the plastic unit, but only a Whatman GF/C glass filter with the Millipore unit. Previous work by Wagemann and Brunskill (Appendix VIII C) had shown that the more completely particulate matter was removed, the lower was the iron concentration in the filtrate. In this investigation iron in filtrates obtained with the more efficient filtration unit, Falcon plastic, was lower than in filtrates obtained with the Millipore filtration unit, and this is in agreement with previous work.

Filtration was performed at three different locations, Fort Simpson (Simp.), Yellowknife (YK.), and Winnipeg (Wpg.) by a different person at each location using the same type of filtration apparatus. The time lapse between collection of sample and filtration was different at each location: one day for Fort Simpson, one to two weeks for Yellowknife and two to four weeks for Winnipeg. The geographic location itself where filtration was performed is naturally not considered to have any influence on analytical results. Filtrations performed in Yellowknife resulted in somewhat higher average concentrations of major cations in the filtrate, and the corresponding particulate matter was higher in PC, but lower in PP and PN compared with filtrates or particulate matter obtained at the other filtration sites. When overall precision for each type of analysis is taken into consideration, these differences may not be as significant as they first appear to be. The average concentration of TDN was significantly higher in filtrates obtained at Fort Simpson than in filtrates obtained at Yellowknife. This discrepancy is very probably due to the much longer time lapse between collection and filtration for filtrates obtained in Yellowknife compared to filtrates obtained in Fort Simpson.

A comparison of analytical results for acidified and unacidified filtrates can be made only for major cations and iron. Major cation concentration was not significantly different in acidified and unacidified filtrates, but iron was substantially higher in acidified filtrates than in unacidified filtrates. It does appear that sample preservation by acidification is necessary if iron is to be retained in solution. Under some conditions this may also be important for retention of some major cations, but under conditions of this investigation this appeared to be unnecessary.

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Table I. Precision estimates of chemical data for Liard River water (at Ft. Simpson) derived from six (*) and twelve (#) separately collected field samples respectively.

Filt'n. Loc'n.		Falcon Plastics Filtration Unit with Sartorius Membrane, 0.45 μm Sartorius Glass Filter						Millipore Glass Filtration Unit with Whatman GF/C Glass Filter					
		Filtrate Acidified			Filtrate not Acidified			Filtrate Acidified			Filtrate not Acidified		
		$\bar{x}$	σ‡	%†	$\bar{x}$(*)	σ	%	$\bar{x}$(#)	σ	%	$\bar{x}$ (*)	σ	%
Simp.	Na^+	2.42#	0.23	9.6				1.72	0.08	4.7			
Yk.	mg/l	2.75*	0.61	22									
Wpg.		2.29#	0.24	10	2.36	0.31	13	1.59	0.04	2.4	1.57	0.04	2.8
Simp.	K^+	0.64#	0.03	5.2				0.52	0.08	16			
Yk.	mg/l	0.78*	0.05	6.4									
Wpg.		0.68#	0.05	7.8	0.69	0.13	19	0.74	0.03	3.4	0.75	0.03	4.0
Simp.	Ca^{++}	28.6#	2.22	7.8				26.9	2.84	11			
Yk.	mg/l	34.5*	0.81	2.3									
Wpg.		30.2#	2.17	7.2	30.1	1.55	5.1	33.2	1.02	3.1	33.6	0.68	2.0
Simp.	Mg^{++}	7.60#	0.16	2.1				7.40	0.28	3.8			
Yk.	mg/l	8.39*	0.14	1.7									
Wpg.		7.80#	0.22	2.8	7.72	0.18	2.3	8.46	0.14	1.6	8.36	0.04	0.5
Simp.	Fe												
Yk.	mg/l	0.15*	0.12	80				0.66	0.13	19	0.18	0.08	44
Wpg.													
Simp.	TDP	22.0#	12.0	55									
Yk.	μg/l	27.1#	28.5	105									
Wpg.													
Simp.	TDN	599 #	160	27									
Yk.	μg/l	210*	19	9.1									
Wpg.													
Simp.	Si				2040#	55	2.7						
Yk.	μg/l				2115	34	1.6						
Wpg.													
Simp.	SO_4^{--}												
Yk.	mg/l				18.1	2.5	14						
Wpg.					27.2	1.1	4.0				23.7	0.3	1.3
Simp.	Cl^-												
Yk.	mg/l				0.64	9.77	120						
Wpg.					0.83	0.39	47				0.89	0.41	46
Simp.	HCO_3^-	117#	1.3	1.1									
Yk.	mg/l	108*	1.3	1.2	analysed on unfiltered sample solution								
Wpg.													

‡ $\sigma = \sqrt{\frac{\Sigma(\bar{x} - x_i)^2}{n - 1}}$; † $\% = \frac{\sigma}{\bar{x}} 100$

Table II. Precision estimates of chemical data for Liard River Water derived from six (*) and twelve (#) repeated analyses of a single large field sample.

Filt'n. Loc'n.		Falcon Plastics Filtration Unit with Sartorius Membrane, 0.45 µm Sartorius Glass Filter: Filtrate Acidified $\bar{x}$	σ	%	Filtrate not Acidified $\bar{x}$(*)	σ	%	Millipore Glass Filtration Unit with Whatman GF/C Glass Filter: Filtrate Acidified $\bar{x}$ (#)	σ	%	Filtrate not Acidified $\bar{x}$(*)	σ	%
Simp.	Na^+ mg/1												
Yk.		3.16*	0.26	8.2									
Wpg.		2.33#	0.27	11	2.32	0.27	12	1.57	0.05	3.0	1.67	0.05	3.0
Simp.	K^+ mg/1												
Yk.		0.76*	0.02	2.6									
Wpg.		0.69#	0.10	15	0.64	0.03	4.7	0.75	0.07	8.8	0.78	0.05	6.4
Simp.	Ca^{++} mg/1												
Yk.		34.1*	0.71	2.1									
Wpg.		32.5#	2.31	7.1	32.5	2.12	6.5	34.3	1.48	4.3	34.7	0.89	2.6
Simp.	Mg^{++}												
Yk.		8.37*	0.08	1.0									
Wpg.	mg/1	7.80#	0.23	2.9	7.80	0.19	2.4	8.38	0.21	2.5	8.36	0.09	1.1
Simp.													
Yk.	Fe	0.05*	0.003	6.0									
Wpg.	mg/1							0.41	0.10	25	0.12	0.03	25
Simp.													
Yk.	TDP	18.5*	4.5	24									
Wpg.	µg/1												
Simp.	TDN µg/1												
Yk.		192*	23.4	12									
Wpg.													
Simp.	Si µg/1												
Yk.					2112	37	1.8						
Wpg.													
Simp.	SO_4^{--}												
Yk.					18.3	5.0	27	sample solution centrifuged					
Wpg.	mg/1				26.9	1.5	5.6				24.7	0.40	1.6
Simp.	Cl^- mg/1												
Yk.					1.70	1.92	113	sample solution centrifuged					
Wpg.					0.87	0.46	53				0.83	0.29	35
Simp.	HCO_3^- mg/1												
Yk.													

Table III. Precision estimates of chemical data for particulate suspended matter of Liard River. PP = particulate phosphorus, PN = particulate nitrogen, PC = particulate carbon, SS = total suspended sediment.

		Derived from six (*) or twelve (#) separately collected field samples						Derived from six (*) repeated analyses of a single large field sample.					
Filt'n. Loc'n.		PLASTIC Filtration Unit Sartorius Glass Filter			MILLIPORE Filtration Unit Whatman GF/C Glass Filter			PLASTIC Filtration Unit Sartoris Glass Filter			MILLIPORE Filtration Unit Whatman GF/C Glass Filter		
		$\bar{x}$	σ	%	$\bar{x}$ (*)	σ	%	$\bar{x}$ (*)	σ	%	$\bar{x}$(*)	σ	%
Simp.	PP												
Yk.	μg/1	113*	11	9.7				107	13	12			
Wpg.		198*	22	11	438	44	10	168	34	20	375	34	9.1
Simp.	PN	778#	220	28									
Yk.	μg/1	546*	120	22				542	109	20			
Wpg.		826*	209	25	1208	59	4.9	858	44	5.1	950	129	14
Simp.	PC	8813#	2879	35									
Yk.	μg/1	13834*	2228	16				15084	1647	11			
Wpg.		9022*	3417	38	21890	6673	30	10702	1707	16	17267	4319	25
Simp.	SS												
Yk.	mg/1	699*	82	12	646	59	9.1	650	84	13			
Wpg.													

Table IV. Sodium ion concentration in Liard River water as a function of glass fibre filter treatment and filter brand.

Method of Separation	Number of Analyses With H+	Number of Analyses No H+	Na concentration in mg/1. Filtrate Acidified	Na concentration in mg/1. Filtrate Not Acidified
Blank (Demineralized Water)	2	1	0.01*	0.07*
Plastic Apparatus Sartorius Glass Fibre (Ignited) Sartorius Membrane (0.45 µm)	2	2	2.87	2.86*
Plastic Apparatus Sartorius Glass Fibre (Unignited) Sartorius Membrane (0.45 µm)	1	1	2.63	2.64
Glass Millipore Apparatus Sartorius Glass Fibre (Ignited)	1	1	2.27	2.39
Glass Millipore Apparatus Sartorius Glass Fibre (Unignited)	1	1	2.35	2.44
Glass Millipore Apparatus Whatman GF/C Glass Fibre (Ignited)	2	1	2.18*	2.16*
Glass Millipore Apparatus Whatman GF/C Glass Fibre (Unignited)	2	1	1.88*	1.92*
Centrifuged 7000 r.p.m. 10 min.	2	2	1.53	1.56

* Indicates samples re-analysed either 20 minutes or one week later, and the results checked very closely.

Table V. Analytical Precision Estimates

	Level	Multiple Sampling Coefficient* of Variation %	Single Sample Coefficient of Variation %
	mg/1		
Na^+	1.5-3	2.5-10	3-12
K^+	0.7-0.8	3.5-8	2.5-9
Ca^{++}	30-35	2-8	2 -7
Mg^{++}	7.5-8.5	0.5-4	1-3
Fe	0.05-0.66	19-80	6-25
Cl^-	0.65-0.9	46-47	35-53
SO_4^{--}	18-27	1.5-14	1.5-6
HCO_3^-	108-117	1.1-1.2	------
	μg/1		
TDP	18.5-27	55-105	24
TDN	192-599	9-27	12
Si	2040-2120	1.5-3	1.8
PP	107-438	9.5-11	9-20
PN	542-1208	5-28	5-20
PC	9022-21890	16-38	11-25
	mg/1		
Seston	646-700	9-12	13

* Coefficient of Variation = $\frac{\sigma}{\bar{x}}\,100$

$$\sigma = \sqrt{\frac{\Sigma(\bar{x} - x_i)^2}{n - 1}}$$

The symbols have the usual meaning.

APPENDIX VIII C

THE EFFECT OF FILTER-PORE SIZE ON ANALYTICAL CONCENTRATIONS OF SOME TRACE ELEMENTS IN FILTRATES OF NATURAL WATER.

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ABSTRACT

Silver metal membrane filters (pore-sizes 5 to 0.2 μm) and Millipore membrane filters (pore-sizes 5 to 0.25 μm) were used to elucidate the relationship between filtration pore-size and analytically determined concentrations of iron, aluminum, total dissolved phosphorus (TDP), silicon and magnesium in the resulting filtrates. River water from the Arctic Red River, N.W.T., Canada was used. Analytically determined concentrations of iron and aluminum decreased with decreasing filter pore-size. For the same nominal pore-size different concentrations of iron, aluminum and silicon were found in filtrates obtained with the two types of membrane filter. Changing filter pore-size did not cause significant variation in analytically determined concentrations of magnesium and silicon in the filtrate.

INTRODUCTION

It is generally recognized that particulate matter in the water sample and adsorption on these solids are two chief causes of analytical error in determination of trace elements in lake or river water samples. Residual particulate matter in solution was implicated as the cause of variation in the analysis of iron in sea water by Spencer and Brewer (1969) and Einsele (1936). The analysis of dissolved phorphorus in lake water by Chamberlain (1968) and Rigler (1964) and others showed that analytical concentration of "dissolved" phosphorus varied systematically with pore-size of filter used to filter the lake water sample prior to analysis. Substantially lower concentrations of "dissolved" phosphorus were obtained for the same water sample when filtered through a 0.1 μm or 0.22 μm pore-size filter membrane than when filtered through a 0.45 μm membrane. For lake and river waters the analytical concentration, at least in the case of phosphorus, is now recognized to be an operationally dependent quantity. "Solution" concentration data which are based on an operational distinction between dissolved and colloidally dispersed or particulate matter are useful and acceptable for certain applications, but are of limited value for thermodynamic calculations. For example, the use of such concentration data for calculating whether concentration limits imposed by various solubility products have been exceeded in natural waters could lead to erroneous conclusions. Such concentrations do not necessarily represent dissolved species only, a requirement imposed by the nature of equilibrium thermodynamics. More information on the influence of some methodological variables such as filter pore-size on analytical concentration of species other than phosphorus is required not only for improving consistency and accuracy of analytical data in general, but also for better understanding of the mechanisms which control solubility and distribution of trace elements in natural waters. Very little is known about the analytical concentration dependence on pore-size of species other than phosphorus in natural water.

This paper presents "solution" concentration data for iron, aluminum , silicon, phosphorus, and magnesium in a river water sample (unpolluted by man) as a function of filter pore-size for two types of membrane filter: silver metal, and Millipore (mixed esters of cellulose).

METHODS AND MATERIALS

Sample Description:

Twenty liters of river water were collected in polyethylene carboys from the

Arctic Red River at Martin House (66°47'18"W x 135°5'12"N) and from the Mackenzie River just upstream of Norman Wells (65°15'57"W x 126°49'24"N) respectively, on September 12, 1971. These bulk water samples were stored at 5°C for six months, and equilibrated for one month at room temperature prior to filtration and chemical analysis. The relatively long storage and equilibration times served to reduce changes in ionic concentration during the course of the experiments.

Filtration:

Two kinds of membrane filters of various pore-sizes were used, MF-Millipore (mixed esters of cellulose), 142 mm in diameter, of average pore-size 5 μm, 3 μm, 1.2 μm, 0.8 μm, 0.45 μm, 0.2 μm, 0.1 μm, 0.05 μm, 0.025 μm; and "Selas Flotronics" silver metal filters, 47 mm in diameter, of average pore-size 5 μm, 3 μm, 0.8 μm, 0.45 μm, 0.2 μm. The pore-sizes quoted are those given by the respective manufacturers. A "Millipore, Teflon, 142 mm" filter holder and a stainless steel "MMH-47, Flotronics" filter holder were used with the two types of membrane filters. Nitrogen gas at 20 psi or less served as a pressure medium for filtration. Membrane filters were soaked prior to use in distilled, demineralized water acidified with hydrochloric acid to pH2, for approximately 24 hours, and then washed with 3 liters of distilled, demineralized water. For each filter the final 400 ml portion of this wash water was retained as a blank. Unless analysis of the blank showed that the filtration system itself produced no significant concentration for the species to be analysed results were discarded and filtration was repeated. As an additional precaution the first 50 to 100ml portion of river water filtrate from each membrane used was discarded. While the bulk river water was stirred with a teflon coated stirrer, a 500 to 550 ml subsample was withdrawn,of which three 150ml portions were filtered with each membrane and collected in three clean polyethylene bottles. One bottle was acidified with hydrochloric acid to pH 1.5, the other bottle was acidified to the same pH with nitric acid, and the third bottle was unacidified. Only high-purity ("Ultrex") acids were used.

Analyses:

Magnesium was determined directly by conventional flame atomic absorption spectroscopy using a Perkin Elmer Model 403 instrument. Machine settings and the analytical methods were those given in the Perkin Elmer methods manual "Analytical Methods for Atomic Absorption, March 1971." Silicate in solution was determined by the molybdate/stannous chloride method of Armstrong and Butler (1962). Total dissolved phosphorus (TDP) was determined as the orthophosphate by the method of Murphy and Riley (1962) (molybdate/antimony/ascorbic acid), after UV-irradiation of the solution by the technique of Armstrong and Tibbits (1968), and Henriksen (1970). Spectrophotometric measurements were made with a Bausch and Lomb Spectronic 400 spectrophotometer. Iron and aluminum were determined directly in the filtrate without preconcentration or extraction, by the flameless atomic absorption method using an HGA 70 Perkin Elmer graphite cell unit and a Perkin Elmer Model 403 spectrophotometer. Analytical sample volumes of 50 μl (injected with an Eppendorf pipette) were used, and the instrument was calibrated against standards prepared daily from 1,000 ppm stock solutions. The basic principles and operational techniques of the graphite tube analytical method were described in detail by Massmann (1968), and Manning and Fernandez (1970). Papers by Paus (1971), and Kahn (1971) deal with the

application of this method to analysis of natural water for trace metals. Estimates of analytical precision for the methods and elements in question were established from separate experiments. The precisions for each element in terms of coefficient of variation are given in the following table:

Element	Coeff. of Var. $\frac{\sigma}{\text{Av. Conc.}} \times 100$	Range of Conc. to which Coeff. of Var. applies	Limit of Reliable Measurement
Mg	2	10-15 mg/l	0.05 mg/l
Si	2	1-4.5 mg/l	1 μg/l
TDP	34	7 μg/l	5 μg/l
Fe	4	50 μg/l	5 μg/l
Al	3	20 μg/l	5 μg/l

RESULTS AND DISCUSSION

In Tables I and IIIare given the analytical concentrations of total "dissolved" iron, total "dissolved" aluminum and total "dissolved" phosphorus (TDP), in acidified and unacidified filtrates of a river water sample as a function of membrane filter pore-size, for metal and "Millipore" type membranes. Two findings are immediately apparent from these data:

1) for both types of membrane filter the analytical concentration of iron, aluminium, and TDP in the filtrate depends on pore-xize of the membrane,

2) for two different types of membrane, "Millipore" and metal, having the same nominal pore-size, analytical concentrations are not the same in the case of iron and aluminium.

Since discussion that follows is based on the contention that observed changes in analytical concentrations of chemical species are related to filter pore-size, it is appropriate to state at the outset the facts in support of this contention. The analytical precision for each element determination was established in separate experiments. Changes in analytical concentrations of iron and aluminium which arose concomitantly with a change in pore-size of membrane filter were much too large in most instances to be accounted for by analytical imprecision alone. Two separate filtrations using the same bulk water sample were performed for each pore-size, each with a new membrane filter (the average concentration from the two filtrations is given for each pore-size) and for each filtration series a concentration dependence on pore-size was evident. In addition, a filtration series using a different river water sample (Mackenzie River, near Norman Wells, N.W.T.) was performed with Millipore membranes of different pore-size, and a concentration dependence on pore-size was evident in this case also. Data for the Arctic Red River water sample only are given here.

For Millipore type membranes the systematic change in analytical concentration occurs in the range of pore-size approximately 0.8 μm to 0.25 μm, and for metal membranes in the range of approximately 5 μm, to 0.8 μm. Analytically

determined concentrations of iron and aluminum were invariably significantly higher in filtrates obtained with large-pore filters (5 μm, and 3 μm) than those obtained with small-pore filters (0.2 μm to 0.25 μm), and this is possibly caused by a higher concentration of residual particulate matter in the former filtrates. The possibility that the observed concentration dependence on filter pore-size for iron and aluminum was caused by filter adsorption or ion exchange cannot be completely excluded, but the following speaks against such a source being the dominant cause of the concentration decrease with decreasing pore-size. All Millipore membranes used in these experiments were 142 mm in diameter while the metal membranes were only 47 mm in diameter. For a larger surface area (by a factor of 9), a reduction of ion concentration in the filtrate was more probable for filtrates obtained with the larger Millipore membranes than with metal membranes, but the opposite was found to be true in most cases (Table I). It was observed that the smaller metal filters were overloaded with sediment during filtration while Millipore filters were not. This may have resulted in a more complete removal of suspended particulate matter by the smaller metal filter compared to the larger Millipore filter of the same nominal pore-size, with consequently lower analytically determined concentrations in the filtrate (Table I).

When iron and aluminum concentrations are compared for filtrates acidified with hydrochloric acid and filtrates acidified with nitric acid it appears that a reduction in concentration results from hydrochloric acid in the filtrate when the concentration of these metals is relatively high (as in filtrates obtained with the 5 μm and 3 μm pore-size membranes). The possibility that the observed effect was specific to the method of analysis employed here for determining these metals, namely flameless atomic absorption was considered. Aluminum chloride has a relatively low temperature of sublimation, 178°C, and that of iron chloride is only somewhat higher, 300°C. Loss of these metal chlorides by sublimation during the charring segment of the analytical cycle was a possible cause of the depressing effect of hydrochloric acid on the concentrations of these elements. This explanation was not sustained by initial results from subsequent experiments.

With regard to total dissolved phosphorus (TDP, see Table III), it should be pointed out that TDP in the river water sample was below or near the limit of detection. This circumstance delimits the usefulness of these data for verifying a concentration dependence on filter pore-size. Such a dependence is to some extent indicated by the fact that filtrates obtained with membranes of 5 μm pore-size are in most cases somewhat higher in TDP than filtrates obtained with 0.45 μm or smaller pore-size membrane filters, which is in agreement with Rigler's (1964) work.

In contrast to iron and aluminum , silicon and magnesium concentrations were not affected by a variation in filter pore-size as is evident from data in Table II. However, a substantial difference in silicon concentration in filtrates obtained with a metal membrane filters and Millipore membranes exists which clearly indicates a systematic analytical error. Since these data were not obtained all at the same time, the possibility of a concentration dependence on time arose despite long preanalysis equilibration, and this was investigated by repeating all silicon analyses after one month. The redetermined values differed only little from the original concentrations and passage of time was therefore not the cause of the discrepancy. Whatever the cause, it is apparent that factors other than filter pore-size can cause analytical

concentrations to vary considerably, and such data should therefore be used with discretion in any application calling for absolute rather than relative concentrations.

SUMMARY

Data presented here indicate that much of the analytically determined dissolved iron and aluminium in river water is particulate matter in the filtrate when this is obtained by filtration with Millipore filters of 0.45 μm pore-size or larger. The actual concentration of dissolved iron and aluminium is substantially lower than analytical concentrations would lead to believe. Depending on pore-size of the filter a rather wide range of analytical concentrations for iron and aluminum can be obtained in the same sample of river water. Indications are that this is also true for total "dissolved" phosphorus. These results emphasize the importance of particulate matter in assessing the concentration of dissolved species such as iron, aluminium and possibly other trace metals. With silver metal filters of pore-size 0.8 μm and smaller, relatively uniform, low analytical concentrations of iron and aluminium were obtained and this may indicate attainment of a separation limit between dissolved and particulate matter, to a degree independent of filter pore-size. The operational definition of a dissolved substance in terms of a 0.45 μm pore-size silver metal membrane may therefore be less arbitrary than in terms of 0.45 μm pore-size Millipore membrane. Analytical concentrations of silicon showed no dependence on filter pore-size, but other unknown factors in the analytical procedure produced discrepancies to warrent caution in using silicon concentration data.

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Table I. Dependence of Analytically Determined Iron and Aluminum in Filtrate, upon Filter Pore-Size, Type of Filter and Acidification of Filtrate in a Water Sample from the Arctic Red River, N.W.T., Canada

Pore Size*	Silver Metal Membranes (Flotronics)			MF-Millipore Membranes	
	47 mm in diam. Total Iron μg/l			142 mm in diam. Total Iron μg/l	
μm	+HCl,pH 1.5	$+HNO_3$,pH 1.5	pH 8.3	$+HNO_3$,pH 1.5	pH 8.3.
0.025	Membrane not procurable			81	45
0.05	Membrane not procurable			161	97
0.1	Membrane not procurable			255	195
0.2	31	32	68	405	310
0.45	23	17	82	525	370
0.8	23	19	94	720	600
1.2	Membrane not procurable			750	650
3	56	384	334	695	670
5	70	247	337	695	1040
μm	Total Aluminum μg/l			Total Aluminum μg/l	
0.025	Membrane not procurable			15	20
0.05	Membrane not procurable			46	42
0.1	Membrane not procurable			54	58
0.2	64	55	64	87	82
0.45	69	53	80	95	88
0.8	66	56	73	160	204
1.2	Membrane not procurable			179	212
3	68	68	122	230	262
5	69	326	290	201	199

* Pore-sizes are quoted from manufacturer's literature.

Table II. Dependence of Analytically Determined Magnesium and Silicon on Filter Pore-Size, Type of Filter and Acidification of Filtrate in a Water Sample from Arctic Red River, N. W.T. Canada.

Pore Size*	Silver Metal Membranes (Flotronics)			MF-Millipore Membranes	
	47 mm in diam.			142 mm in diam.	
	Magnesium mg/l			Magnesium mg/l	
µm	+HCl,pH 1.5	$+HNO_3$,pH 1.5	ph.8.3	$+HNO_3$,pH 1.5	pH 8.3
0.025	Membrane not procurable			13.8	14.3
0.05	Membrane not procurable			13.8	14.6
0.1	Membrane not procurable			14.2	14.1
0.2	13.0	13.0	12.9	13.4	14.1
0.45	12.9	13.0	12.9	13.7	14.1
0.8	12.9	13.0	12.9	13.9	14.1
1.2	Membrane not procurable			14.2	14.1
3	13.0	13.0	13.0	13.5	14.6
5	12.9	13.0	12.8	13.7	14.3
µm	Silicon mg/l			Silicon mg/l	
0.025	Membrane not procurable			1.74	1.92
0.05	Membrane not procurable			1.53	1.54
0.1	Membrane not procurable			1.54	1.51
0.2	2.06	2.05	2.10	1.53	1.54
0.45	2.08	2.09	2.08	1.57	1.53
0.8	2.09	2.09	2.09	1.56	1.54
1.2	Membrane not procurable			1.58	1.56
3	2.11	2.10	2.10	1.58	1.55
5	2.11	2.17	2.13	1.59	1.56

* Pore-sizes are quoted from manufacturer's literature.

Table III. Dependence of Analytically Determined Total Dissolved Phosphorus (TDP) in the Filtrate on Filter Pore-Size, Type of Filter and Acidification of Filtrate in a Water Sample from Arctic Red River, N.W.T., Canada.

Pore-Size	Silver Metal Membranes (Flotronics)			MF-Millipore Membranes	
	47 mm in diam. TDP μg/l			192 mm in diam. TDP μg/l	
μm	+HCl, pH 1.5	$+HNO_3$, pH 1.5	pH 8.3	$+HNO_3$, pH 1.5	pH 8.3
0.25	Membrane not procurable			<5	<5
0.05	Membrane not procurable			<5	<5
0.1	Membrane not procurable			<5	<5
0.2	<5	<5	<5	<5	<5
0.45	<5	<5	<5	<5	<5
0.8	<5	<5	<5	<5	5
1.2	Membrane not procurable			<5	6
3	<5	<5	<5	<5	8
5	<5	6	7	<5	8

*Pore sizes are quoted from manufacturer's literature.

APPENDIX VIII D

MEMBRANE AND GLASS FIBRE FILTER CONTAMINATION IN CHEMICAL ANALYSIS OF FRESH WATER

R. Wagemann and B. Graham

ABSTRACT

The extent of filtrate contamination with major cations, Si, TDP and TDN from Sartorius and Millipore membrane filters and Gelman, Sartorius and Whatman glass fibre filters was determined. Millipore membranes and the Sartorius cellulose nitrate membranes, when not washed before use, caused significant TDN contamination of filtrate, and Sartorius and Gelman glass fibre filters caused contamination of filtrate with sodium ion. Carbon and nitrogen in ignited and unignited glass fibre filters were measured, and ignition of filters before use was found essential for accurate determination of carbon and nitrogen in particulate matter of most fresh waters.

INTRODUCTION

In the process of filtering lake or river water prior to chemical analysis, the membrane and glass fibre filters commonly used for this purpose can adsorb certain chemical elements. They can also be potential sources of filtrate contamination. Where quantities to be measured in filtrates and in particulate matter retained by filters are very low, the possibility of significant contamination from filters is very real. Systematic errors in concentration due to contamination by filters can arise in two ways: 1) by elution of a contaminant from the filter into the filtrate in the process of filtration and subsequent analysis of the filtrate in ignorance of such a contribution, 2) by contribution of a "background" measurement by the filter as in the analysis of carbon and nitrogen in suspended particulate matter when this is collected on a glass fibre filter.

Consideration of the second point is important because determinations of carbon and nitrogen in suspended particulate matter are now made most frequently with glass fibre filters on which the particulate matter was collected from the water sample. The filter disc together with the collected sample of suspended material is dried and combusted and the resultant gases are analysed by gas chromatography. Ideally, the "background" signal, i.e. the carbon and nitrogen content of the filter disc alone should be insignificant relative to the sample signal. Due to inherent impurities of materials or other factors this is seldom the case. Different commercial filters vary in the size of "background" signal they produce even after they are subjected to ignition treatment.

The object of this work was to measure contamination in filtrates by major cations, silicon, TDP, and TDN resulting from filtration with some well-known brand name filters used commonly in the water chemistry laboratory, and to compare quantitatively carbon and nitrogen concentrations in some commercial glass fibre filters. By comparing the contamination level or "background" signal with the actual concentrations in fresh water the significance of contamination can be gauged.

METHODS AND MATERIALS

Description of filters used	Catalog Number	Batch or Lot Numbers	Manufacturer's Av. Pore-size µm
Sartorius Cellulose Nitrate	11306	120	0.45
Sartorius Cellulose Acetate	11106	671	0.45
Sartorius Glass Fibre	13400	463,263	2-5
MF-Millipore R (mixed esters of cellulose), Plain	HAWP04700		0.45
MF-Millipore R (mixed esters of cellulose), Gridded	HAWG04700		0.45
Gelman Type A, Glass Fibre	61694	8166,8172	2-5
Whatman Glass Fibre	GF/C	056804,1535 15015,14760 150124	2-5

All filters were 47 mm in diameter except the Whatman glass fibre filters which were 42.5 mm in diameter. Filtration was performed with a sterilized, disposable Falcon Plastics #7102 filtration apparatus. Heat treatment (ignition) of glass fibre filters consisted of heating at 525°C for 16 hours (8 hours in some cases) in a "Lindberg Hevi-Duty" furnace. Filters were washed by passing 150 ml of distilled, demineralized water (Super Q) through the filter and discarding the wash water. Demineralized water termed "Super Q" water was obtained by passing distilled water through a "Millipore Super Q" ion exchange column which produced water of 18 megohm resistivity. 150 ml of Super Q water was filtered with each filter to measure contamination from filters. Super Q water was obtained fresh daily, stored for the day in a Nalgene carboy and analyzed daily for the ions of interest before use. Calcium, magnesium, sodium and potassium were determined by conventional flame atomic absorption spectroscopy using a Perkin Elmer Model 403 instrument.

Machine settings and the analytical methods were those given in the Perkin Elmer methods manual, "Analytical Methods for Atomic Absorption, March 1971". Silicate in solution was determined by the molybdate/stannous chloride method of Armstrong and Butler (1962). Total dissolved phosphorus (TDP) was determined as the orthophosphate by the method of Murphy and Riley (1962) (molybdate/antimony/ascorbic acid), after UV-irradiation of the solution by the technique of Henriksen (1970). Spectrophotometric measurements were made with a Bausch and Lomb Spectronic 400 spectrophotometer. The spectrophotometric method of Wood *et al.* (1967) was used for measuring total dissolved nitrogen (TDN). Glass fibre filters were analyzed for carbon and nitrogen with modified Carlo Erba, Model 1102 and Perkin Elmer, Model 240 CHN-analyzer instruments. The modification to the instruments consisted of changing the sample introduction mechanism to accommodate a whole glass fibre filter.

DISCUSSION

Levels of contamination with major cations and nutrients in demineralized water as a consequence of filtering with membrane and glass fibre filters are given in Tables II, III and IV. Each filtrate was analyzed in triplicate (the average is given) and a blank concentration value was subtracted. The blank value was obtained by duplicating the procedure and analysis with demineralized water of the same batch as was used for filtration but omitting the filtration step. The recorded values are therefore a measure of filtrate contamination as a result of filtration. Data of Tables II and III served to indicate which contaminant was introduced in sufficient quantity to warrant performing additional filtrations and analyses. Where this was indicated, as for TDN and sodium, analysis of six different filtrates, each obtained with a new membrane or glass fibre filter, was performed to obtain statistically more valid data, which is given in Table IV. In order to gauge the significance of the measured contamination levels for the analysis of fresh water it is necessary to compare these levels with concentration levels of the species in question actually prevailing in fresh water. Table I gives ranges of concentration for major cations and nutrients in unpolluted river water and lake water.

The data show (Tables II, III and IV) that all membrane filters tested except one can be a source of significant contamination of filtrate with TDN. Major cation, Si, and TDP contamination on the other hand is insignificant from membrane filters. All unwashed membranes, except the Sartorius cellulose acetate membrane, release during filtration some form of nitrogen which is then measured as TDN in the filtrate. This contamination level exceeds in some cases the concentration level of TDN that would be measured in some lake or river water (Table I). As anticipated, the Sartorius cellulose nitrate membrane introduced the highest level of TDN contamination (Table IV), but a reduction to an acceptable level can be effected by washing with distilled, demineralized water prior to use. The Sartorius cellulose acetate membrane introduces the least TDN contamination even when not washed. This membrane appears to have some advantage over others that were tested for measuring low levels of TDN in lake and river water subsequent to filtration. Contamination with TDN from unwashed Sartorius cellulose nitrate and MF-Millipore gridded membranes is highly variable as evidenced by a large standard deviation (Table IV) and this precludes ready application of a correction to allow for such contamination in TDN measurements. The level of TDN contamination from glass fibre filters is not totally insignificant but it is small compared to that introduced by some unwashed membrane filters (Table IV).

Significant contamination of filtrate with sodium ion is caused by the Sartorius glass fibre filter and to a lesser extent also by the Gelman Type A glass fibre filter. Comparison of sodium ion concentrations in Table IV with concentrations in Table I shows that for the most dilute fresh water (particularly ELA lake water) this level of contamination would introduce a large error into sodium ion determination. When the glass fibre filters were heat treated for only four hours at 525°C instead of sixteen, contamination was even higher. Filtrate contamination with sodium ion from Whatman glass fibre filters is insignificant.

Table IV gives the carbon and nitrogen content of some glass fibre filter brands before and after a heat treatment. Before the significance of these quantities or "background" signals can be gauged it is necessary to know the

magnitude of actual sample measurements. Table V gives quantities of carbon and nitrogen in suspended particulate matter measured per 47 mm diameter filter disc. The magnitude of these values is related to the quantity of particulate matter collected on the filter disc, and this in turn depends on the quantity of water filtered and the concentrations of suspended matter in it. These two variables operate in opposition, thereby imposing practical limits on the quantity of particulate matter that can be collected per filter disc within a reasonably short time. The given ranges are therefore arbitrary to a degree but this does not make them any less useful for the purpose of gauging the significance of background signals in carbon and nitrogen analyses of suspended particulate matter.

In comparing data of Table VI with data of Table V, it is evident that in most cases heat treatment of glass fibre filters prior to use is an essential step in the process of determining carbon and nitrogen in particulate matter with reasonable accuracy, otherwise the background signal becomes unreasonably high relative to the sample signal. Even after heat treatment, for some types of water, the quantity of nitrogen in glass fibre filters alone may still be larger than nitrogen in the sample. In such cases the filtration of relatively large quantities of water would increase the accuracy of determinations, but because of time limitations and clogging of filter this is not always a practicable means of increasing the sample to background ratio, particularly in routine sampling and analysis. It is therefore important to choose judiciously the best glass fibre filter for this kind of analysis.

The data of Table VI show that residual carbon and nitrogen in heat treated, unwashed glass fibre filters does not differ greatly for the three different brands tested. Ignited Sartorius filters show a reduction in carbon and nitrogen when washed with demineralized water after ignition. This treatment is clearly of no value for the other two filter brands tested. It would therefore appear that somewhat better accuracy in nitrogen analyses of particulate matter can be attained with ignited and washed Sartorius glass fibre filters than with the other two filters. Except for waters with a high concentration of organic suspended particulate matter, correction for background signal is unavoidable with any of the glass fibre filters tested. Sartorius glass fibre filters contain an organic binder which imparts a very high carbon and nitrogen content to these filters, but this is effectively reduced to a very low level by proper heat treatment. Because of the organic binder in Sartorius filters they are more difficult to ignite. When introduced into a preheated muffle furnace these filters tend to burst into flame and this must be avoided by bringing the filters to maximum temperature gradually.

SUMMARY

All but one of the membrane filters tested, when not previously washed, introduce sufficient TDN into the filtrate to cause serious errors in TDN measurement of unpolluted natural water. The Sartorius cellulose acetate membrane because of low TDN contamination is considered best suited for filtration in conjunction with low TDN measurements. Two glass fibre filters, Gelman and Sartorius, especially the latter, introduce sufficient sodium ion contamination into the filtrate to cause errors in measurement of low levels of sodium ion in natural water. Sodium ion contamination from Whatman glass fibre filters is insignificant. Carbon and nitrogen in glass fibre filters must be corrected for in the analysis of carbon and nitrogen in particulate matter. Sartorius glass fibre filters, after heat treatment and washing contain the least nitrogen. Consequently, this filter is somewhat superior to other filters tested for nitrogen determination in particulate matter.

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Table I. Typical ranges of concentrations of major cations, silicon, total dissolved phosphorus (TDP) and total dissolved nitrogen (TDN) in some lake waters and unpolluted river water.

Element	River Water[1] Conc. Range	E.L.A. Lake Water[2] Conc. Range	Lake Winnipeg Water[3] Conc. Range
	mg/l	mg/l	mg/l
Ca^{++}	13-162	0.6-4.5	6-71
Mg^{++}	2-34	0.5-2.4	2-32 (70)*
Na^{+}	1.5-104 (322)	0.4-1.7	1-42 (310)
K^{+}	0.5-2.0 (6)	0.2-1	0.5-7 (20)
Si	0.5-2.5	1-3	0.01-5
	μg/l	μg/l	μg/l
TDP	8.-42.	3-20	4(0.9) - 104(221)
TDN	110-665	110-300	100(2.2) - 975(1175)

* Values in brackets are extreme values attained occasionally.

1. Data are from preliminary unpublished report to Environmental-Social Committee, December 1972, Appendix IX, Department of Environment, Canada. Concentration ranges represent seven different rivers in the Mackenzie basin for the period 1971-72 (Mackenzie River, Liard River, Arctic Red River, Redstone River, Great Bear River, Willowlake River, Hare Indian River).

2. Data are from J. Fish. Res. Bd. Canada, 28, 171-187, by F. A. J. Armstrong and D. W. Schindler (1971). Concentration ranges represent forty different lakes for the period 1968-69, in the Experimental Lakes Area of northwestern Ontario.

3. Unpublished data, supplied by G. Brunskill, Fisheries Research Board, Winnipeg. Data are for the period 1968-70.

Table II. Level of contamination in demineralized water as a result of filtering through different types of differently treated membrane filters.

Type of Membrane and Treatment	mg/1				µg/1		
	Ca	Mg	Na	K	TDP	TDN	Si
Sartorius Cell. Acetate, not washed	<0.05	<0.05	<0.05	<0.05	<1	<1	1
Sartorius Cell. Acetate, washed	<0.05	0.06	<0.05	<0.05	1	<1	<1
Sartorius Cell. Nitrate, not washed	<0.05	<0.05	<0.05	<0.05	<1	18	1
Sartorius Cell. Nitrate, washed	<0.05	<0.05	<0.05	<0.05	<1	7	<1
MF-Millipore Gridded, not washed	<0.05	0.13	<0.05	<0.05	4	79	<1
MF-Millipore Gridded, washed	<0.05	0.08	<0.05	<0.05	<1	94	<1

Table III. Level of contamination in demineralized water as a result of filtering through different types of glass fibre prefilter superimposed on different types of membrane filters.

Type of membrane and glass fibre filter and treatment of filters	mg/l				µg/l		
	Ca	Mg	Na	K	TDP	TDN	Si
Sartorius Cell. Acetate, not washed and Sartorius Glass Fibre, not washed	<0.05	0.14	0.71	0.05	1	1	8
Sartorius Cell. Nitrate, not washed and Sartorius Glass Fibre* not washed	0.20	<0.05	0.82	<0.05	<1	31	1
Sartorius Cell. Nitrate, not washed and Sartorius Glass Fibre, not washed	<0.05	<0.05	0.76	<0.05	<1	21	11
Sartorius Cell. Nitrate, washed and Sartorius Glass Fibre, washed	0.05	<0.05	0.10	<0.05	<1	4	4
Sartorius Cell. Acetate, not washed and Gelman Glass Type A, not washed	<0.05	<0.05	0.52	<0.05	1	40	<1
MF-Millipore Gridded, washed and Sartorius Glass Fibre, not washed	<0.05	<0.05	0.60	<0.05	<1	33	<1
MF-Millipore Plain, not washed and Sartorius Glass Fibre, not washed	<0.05	<0.05	0.58	<0.05	4	55	<1

* used directly from package without heat-treatment. All other glass fibre filters were heat-treated (16 hours at 525°C) before use.

Table IV. Level of sodium and TDN contamination in demineralized water as a result of filtration with different types of differently treated filters. Results are based on six separate filtrations using a new membrane or glass fibre filter in each case.

Type of filter and treatment		µg/l TDN*	µg/l Stand. Dev.	mg/l Sodium*	mg/l Stand. Dev.
Sartorius Cell. Acetate,	not washed	30	6	<0.05	--
Sartorius Cell. Acetate,	washed	31	16	<0.05	--
Sartorius Cell. Nitrate,	not washed	205	210	0.052	0.012
Sartorius Cell. Nitrate,	washed	50	10	<0.05	--
MF-Millipore Gridded,	not washed	177	158	<0.05	--
MG-Millipore Gridded,	washed	134	69	<0.05	--
MF-Millipore Plain,	not washed	114	73	<0.05	--
MF-Millipore Plain,	washed	53	31	<0.05	--
Sartorius Glass Fibre,**	not washed	33	13	0.70	0.35
Gelman Type A, Glass Fibre,	not washed	31	12	0.22	0.08
Whatman GF/C Glass Fibre,	not washed	35	9.5	0.05	--

* Blank concentrations have been subtracted from recorded values.

** All glass fibre filters were heat-treated for 16 hours at 525°C before use, except the Whatman which were heat-treated for 8 hours at 550°C.

Table V. Typical carbon and nitrogen ranges per filter disk obtained in the analysis of particulate suspended matter collected on glass fibre filters for different lake waters and river water.

	River Water[1] µg/filter	E.L.A. Lake Water[2] µg/filter	Lake Winnipeg Water[3] µg/filter
Carbon	54-332	40-120 -(1300)*	110-1350
Nitrogen	4.5-42	3.0-20 (0.5-70)	10-200

* Values in brackets are extreme values attained occasionally.

1. Based on a filtration volume of 150 ml of water. Source of data used to calculate these values is given in footnote of Table 1.

2. Based on a filtration volume of 100 ml of water. Unpublished data supplied by M. Stainton, Fisheries Research Board, Winnipeg. Given ranges are derived from approximately 2000 analyses representing eight different lakes in the Experimental Lakes Area of Northwestern Ontario, for the period 1968-69.

3. Based on a filtration volume of 500 ml of water. Unpublished data supplied by G. Brunskill, Fisheries Research Board, Winnipeg. Given ranges are derived from 213 separate analyses of Lake Winnipeg water for the period 1968-70.

Table VI. Carbon and nitrogen content in different types of glass fibre filter before and after they were subjected to heat treatment and washing.

Type of glass fibre filter and treatment	μg/filter Carbon	μg/filter Standard Deviation	μg/filter Nitrogen	μg/filter Standard Deviation
Whatman GF/C, not heat treated, not washed	76 (4)*	19	25 (4)	6.9
Whatman GF/C, heat treated, not washed	24 (11)	14	5.4 (12)	1.1
Whatman GF/C, heat treated, washed	31 (6)	5.3	9.5 (6)	6.3
Gelman Type A, not heat treated, not washed	69 (3)		6.4 (3)	
Gelman Type A, heat treated, not washed	20 (13)	5.9	5.4 (13)	1.5
Gelman Type A, heat treated, washed	34 (6)	5.6	6.7	1.2
Sartorius, not heat treated, not washed	255000 (3)		2000 (3)	
Sartorius, heat treated, not washed	27 (9)	2.9	4.5 (8)	2.5
Sartorius, heat treated, washed	19 (6)	7.6	1.2 (6)	1.3

* Numbers in brackets are the number of filters analyzed.

APPENDIX IX

General physical and chemical data for river, stream and lake waters of Mackenzie and Porcupine watersheds, and some figures showing seasonal variations of these parameters in 1971-72.

Table Ia Drainage areas, lengths, and ranges of widths, mean depths, annual discharges and mean velocities at sampling stations of selected rivers and streams. Mackenzie mainstem study area.

LOCATION	(km^2) Ad	(km) length	(meters) Width	Mean Depth	($m^3 \times 10^6$) Annual Discharge	($m\ sec^{-1}$) Mean Velocity
Arctic Red R.	15,100		134-197	1.08-2.69	4,940	0.024-0.890
Flat R.	8,500		31.9-116	0.28-1.62		0.152-2.76
Great Bear R. (Great Bear L.)	146,000		147-149	3.15-3.36	18,000	
Harris R.						0.133-0.653
Jean Marie Creek			4.3-5.2			0.108-0.980
Liard River (Fort Liard)	222,000	684	390-540	1.18-2.50	53,300	0.009-2.93
Mackenzie R. (Fort Providence)	971,000	56.3	1040-1570	1.30-4.45	113,000	0.030-2.10
Mackenzie R. (Above Liard R.)	1,020,000	312	1110-1190	2.13-8.09	122,000	0.067-1.86
Mackenzie R. (Norman Wells)	1,570,000	872	1070-1390	3.84-9.28	247,000	0.034-2.35
Martin R.	1090					0.154-1.33
Peel R.	70,000	550	258-335	1.53-4.05	22,000	0.030-0.975
Rabbitskin R.						0.077-1.40
Redstone R.	15,700	286				0.061-2.61
S. Nahanni (Virginia Falls)	14,600		165-172	1.58-5.06	7,100	0.030-1.45
S. Nahanni (Clausen Creek)	33,400		91.4-180	0.47-2.79	11,300	0.030-2.55
Trail R. (Mackenzie)						0.213-0.448
Trout R.						0.030-1.16
Willowlake R.	21,600	283	67.1-94.5	1.16-5.91	1,440	0.024-1.38

Table IIa Ranges of water temperatures, concentrations of dissolved oxygen, pH and specific conductivity at 25°C measured during 1971-72. Mackenzie mainstem rivers and streams.

LOCATION	(μmho cm^{-1}) Conductivity	(°C) Temperature	(moles m^{-3}) O_2	pH
Arctic Red R.	150-530	-1.4-18	0.33-0.37	7.3-8.1
Blackwater R.	150-460	2.5-16	0.56	7.8-8.2
Bluefish R.	660	18		9.0
Brackett R.	250-450	8.8-21	0.28-0.32	7.7-8.3
Caribou R.		3.0		7.0-7.0
Cranswick R.		6.0		7.5
Flat River	130	5.8		7.8
Great Bear R. (Great Bear L.)	93-140	3.0-9.0		7.6-8.1
Great Bear R. (Brackett R.)	110-170	0.5-7.5	0.35-0.39	7.6-7.7
Hanna R.	180-220	5.0-9.0		7.8-7.8
Hare Indian R.	230-660	0.5-17	0.28-0.36	7.3-8.2
Harris R.	170-450	2.0-22	0.12-0.30	7.3-8.1
Horn R.	140-500	5.5-18	0.27-0.39	7.7-8.5
Hume R.		5.5		7.5
Jackfish Creek	230	12		8.4
Jean Marie Creek	160-580	0.1-22	0.19-0.39	7.6-8.5
Johnny Hoe R.	120-240	17-20		7.6-8.2
Liard R. (Fort Liard)	93-390	0.0-14	0.19-0.50	7.8-9.0
Liard R. (Mackenzie R.)	100-440	-0.5-19	0.16-0.34	7.7-8.7
Lower Beaver Creek		6.5		7.5
Mackenzie R. (Fort Providence)	160-240	-0.2-17	0.22-0.39	7.3-8.2

Table IIa	Conductivity	Temperature	O_2	pH
Mackenzie R. (Above Liard R.)	110-290	-0.1-18	0.17-0.49	7.7-8.6
Mackenzie R. (Wrigley)	155	10		7.8
Mackenzie R. (Norman Wells)	150-330	0.1-16	0.23-0.33	7.7-8.2
Mackenzie R. (Fort Good Hope)	150	10		7.7
Mackenzie R. (Arctic Red R.)	200-220	8.3-18	0.30-0.34	7.3-7.9
Martin R.	140-580	0.0-21	0.09-0.39	7.5-8.4
Mosquito Creek	1700	16		8.1
Mountain R.	70-330	0.1-10	1.2	7.7-8.1
Ontaratue R.		5.0-6.0		7.0-7.5
Peel R.	<40-310	0.2-18	0.16-0.36	7.0-8.1
Petitot R.	140-380	13-18		8.0-8.3
Rabbitskin R.	180-1100	0.0-21	<0.01-0.36	7.2-8.6
Ramparts R.		5.0-5.5		7.0-7.5
Redknife R.	440	18		8.4
Redstone R.	150-800	-0.2-14	0.19-0.38	7.7-8.3
Road River		3.0-8.0		7.0-7.5
Sainville R.		6.0-8.0		6.5-7.5
Saline R.	760-2500	6.0-20	0.53	7.8-8.4
Satah River		5.0		7.0
Secret Creek	200	15	0.26	8.2
Snake River		4.0		7.5
S. Nahanni (Virginia Falls)	150-350	0.0-10	0.16-0.43	7.8-8.0
S. Nahanni (Clausen Creek)	110-260	5.0-13	0.50	7.8-8.1
Stony Creek		2.5-7.0		7.5
Trail R. (Mackenzie)	83-530	0.1-19	0.17-0.37	6.9-8.2
Trail R. (Peel R.)		0.0-15	0.26-0.28	7.5

Table IIa	Conductivity	Temperature	O_2	pH
Trout River	85-170	6.3-20	0.29-0.39	7.5-8.2
Vittrekwa R.		2.5-7.0		5.0-8.0
Weldon Creek		6.5-7.5		6.5-7.5
Willowlake R.	59-2100	0.0-21	0.15-0.29	7.3-8.1
Wind River		4.0		8.0

Table IIb Ranges of water temperatures, concentrations of dissolved oxygen, pH and specific conductivity at 25°C measured during 1971-72. Yukon rivers and streams.

LOCATION	(μmho cm^{-1}) Conductivity	(°C) Temperature	(moles m^{-3}) O_2	pH
Bell River	110-390	7.3-17		7.5-8.6
Bluefish R.	170-290	0.0-17		7.5-8.5
Branch R.		9.5		7.0
Caribou Bar Creek	18-110	0.0-16	0.26-0.33	5.9-7.9
Driftwood R.	43-61	6.5-14		6.5-7.5
Eagle R.	190	9.5-21		7.5-7.7
Joe Creek	92	7.4-17	0.44	7.1-7.5
Lord Creek	88	8.4-13		6.8-7.5
Miner River		9.5		8.0
Old Crow R.	28-270	7.8-18		6.6-8.2
Old Crow Creek		5.6		8.2
Pine Creek		15		7.5
Porcupine R.	100-230	7.8-18		7.3-8.1
Potato Creek		5.6		6.5

Table IIb	Conductivity	Temperature	O_2	pH
Summit Lake Outlet	400	13		8.0-8.5
Timber Creek		9.0		8.0

Table IIc Ranges of water temperatures, concentrations of dissolved oxygen, pH and specific conductivity at 25°C measured during 1971-72. Mackenzie Delta channels and sea, rivers and streams.

LOCATION	(μmho cm^{-1}) Conductivity	(°C) Temperature	(moles m^{-3}) O_2	pH
Aklavik CH - 1	200-400	6.5-6.6		8.0
Anderson R.	120-190	1.5-13		7.4-8.0
Beaufort Sea - 13	3800-22000	-0.2-9.0	0.34	7.7-8.1
Beaufort Sea - 14		7.2-8.8		7.9-8.1
Beaufort Sea - 15	340-17500	0.0-11	0.19-0.48	5.9-8.0
Beaufort Sea - 18	14500-17700	4.5-4.9		8.0
Beaufort Sea - 19	16900-21100	4.3-4.5		8.0
Beaufort Sea - 20	12600-18500	3.6-4.1		7.9
Beaufort Sea - 21	3600-3700	3.3-3.6		8.1
Beaufort Sea - 22	200	4.1-4.2		8.2
Beaufort Sea - 23	250-350	7.4-7.6		8.2
Beaufort Sea - 24	350-2500	1.0-14	0.31-0.45	7.7-8.3
Beaufort Sea - 26	400-4800	0.5-11	0.33-0.44	7.7-7.9
Blow River		5.6		6.5
Campbell Creek	52-220	0.0-22	0.06-0.39	6.4-7.2
East CH - 1	150-500	0.0-16	0.16-0.43	7.6-7.9
East CH - 3	260-350	0.0-15	0.15-0.42	7.5-8.1

Table IIc	Conductivity	Temperature	O_2	pH
East CH - 4	100-350	0.0-15	0.18-0.34	7.6-8.1
East CH - 6	250-300	7.9-8.4		7.7-7.9
East CH - 7	100-400	0.0-16	0.30-0.31	7.4-8.0
East CH - 8	300	8.8-9.3		7.9
East CH - 9	200-300	7.4-9.1		8.1
Firth River		2.9-7.9		7.4-7.8
Gully CH - 1	310-500	11-18	0.31-0.32	6.9-7.6
Hope CH		12		8.1
Jamieson CH - 1	100-400	5.9-14	0.32	7.6-8.0
Jamieson CH - 2	200-300	7.5-8.0		7.9-8.1
Kugmallit Bay - 4	200-11000	0.0-12	0.17-0.50	7.5-8.3
Kugmallit Bay - 5	200-700	0.0-11	0.34-0.59	7.7-8.0
Kugmallit Bay - 6	280-440	0.0-11	0.17-0.33	7.7-8.0
Kugmallit Bay - 7		6.1-6.5		7.9
Kugmallit Bay - 8		6.8-11	0.39	7.9-7.9
Kugmallit Bay - 17	300-350	7.1-7.2		8.2
Main CH - 1	100-300	0.0-15	0.17-0.44	7.4-8.1
Main CH - 3	300-500	8.0-16	0.30	7.4-8.1
Main CH - 4	300-350	7.6-9.4		7.6-8.0
Main CH - 5	250-300	7.7-9.5		8.1
Napoiak CH - 1	200-360	6.9-14		7.7-8.0
Napoiak CH - 2	300-350	8.3-8.9		7.8-7.9
Peel CH - 1	100-300	6.9-7.1		8.0
Peel CH - 2	150-300	4.8-6.2		7.9
Peel CH - 3	200-300	4.5-4.9		7.9
Rengleng R.		0.0	0.19	6.6-6.7

Table IIc	Conductivity	Temperature	O_2	pH
Shallow Bay	350	7.4-7.5		7.9
West CH - 1	150-380	0.0-15	0.29-0.33	7.5-7.9
West CH - 2	250-420	7.3-15	0.31-0.34	7.7-8.0
West CH - 3	280	17	0.30	7.7

NOTE: CH = Channel
3 = Station No. 3

Table IId Ranges of water temperatures, concentrations of dissolved oxygen, pH and specific conductivity at 25°C measured during 1971-72. Mackenzie Delta lakes.

LOCATION	(μmho cm^{-1}) Conductivity	(°C) Temperature	(moles m^{-3}) O_2	pH
Boot Lake		15	0.31	7.6
Denis Lake		8.8		8.2
East Channel L.	250-280	2.2-16	0.15-0.43	7.5-8.2
Shell Lake	88-300	0.0-6.6	0.22-0.38	6.7-7.0
Y Lake		8.8-9.1		8.1
Lake 1	200-950	0.0-18	0.18-0.44	7.4-8.1
Lake 2	250	4.0		9.1
Lake 3	280-580	1.0-17	0.29-0.40	7.5-8.0
Lake 4	170-600	0.0-17	<0.01-0.53	7.0-9.6
Lake 4C	55	0.0	0.05	7.6
Lake C4	160-440	0.0-17	0.00-0.48	7.0-9.6
Lake 5	210-450	4.5-18	0.22-0.31	6.9-8.9
Lake 6	400	4.7		8.2
Lake 7	180-330	0.0-14	0.22-0.39	7.0-8.6
Lake 11	100-320	6.4-8.2	0.38	7.3-8.6
Lake 12	150-280	4.9-12	0.33-0.38	7.0-8.1

Table IIIa Ranges of concentrations of total dissolved calcium, magnesium, sodium and potassium measured during 1971-72. Mackenzie mainstem rivers and streams.

	(moles m^{-3})			
LOCATION	Ca	Mg	Na	K
Arctic Red R.	0.69-1.9	0.29-0.68	0.09-0.44	0.02-0.02
Blackwater R.	0.59-1.0	0.41-0.64	0.51-1.5	0.02-0.03
Bluefish R.	1.5	2.0	0.80	0.29
Brackett R.	0.56-0.91	0.37-0.63	0.75-1.8	0.02-0.05
Caribou R.	0.41-0.91	0.18-0.57	0.11-0.31	0.01-0.02
Cranswick R.	0.76	0.54	0.15	0.01
Flat River	0.60	0.27	0.07	0.02
Great Bear R. (Great Bear Lake)	0.31-0.38	0.25-0.27	0.12-0.16	0.02-0.02
Great Bear R. (Brackett R.)	0.34-0.39	0.21-0.30	0.18-0.22	0.02-0.02
Hanna R.	0.67-0.79	0.32-0.45	0.17-0.19	0.02-0.02
Hare Indian R.	0.33-4.0	0.41-0.83	0.14-0.25	0.02-0.03
Harris R.	0.54-1.7	0.29-0.88	0.16-1.8	0.02-0.05
Horn River	0.58-1.3	0.33-0.76	1.2-2.4	0.04-0.05
Hume River	0.79	0.40	0.10	0.01
Jackfish Creek	0.76	0.42	0.23	0.01
Jean Marie Creek	0.65-2.2	0.26-0.81	0.16-0.75	0.02-0.05
Johnny Hoe R.	0.58-0.62	0.36-0.48	0.16-0.28	0.02-0.03
Liard R. (Fort Liard)	0.58-1.4	0.25-0.72	0.09-0.18	0.01-0.05
Liard R. (Mackenzie R.)	0.56-1.5	0.22-0.74	0.07-0.26	0.01-0.03
Lower Beaver Creek	0.64	0.34	0.20	0.01
Mackenzie R. (Fort Providence)	0.64-0.92	0.19-0.35	0.28-0.38	0.03-0.03

Table IIIa	Ca	Mg	Na	K
Mackenzie R. (above Liard R.)	0.61-0.92	0.17-0.34	0.28-0.42	0.02-0.04
Mackenzie R. (Wrigley)	0.65	0.28	0.27	0.03
Mackenzie R. (Norman Wells)	0.64-2.3	0.30-1.4	0.21-1.1	0.02-0.04
Mackenzie R. (Fort Good Hope)	0.69	0.29	0.21	0.03
Mackenzie R. (Arctic Red R.)	0.73-0.99	0.32-0.63	0.23-2.9	0.02-0.03
Martin River	0.48-2.2	0.12-0.79	0.11-0.50	0.01-0.06
Mosquito Creek	12	1.3	0.18	0.05
Mountain R.	0.65-2.0	0.33-1.0	0.08-0.41	0.02-0.04
Ontaratue R.	0.44-0.64	0.18-0.36	0.14-0.20	<0.01-0.03
Peel River	0.62-1.5	0.26-0.79	0.08-4.0	0.01-0.03
Petitot R.	0.63-1.0	0.23-0.44	0.11-0.42	0.02-0.03
Rabbitskin R.	0.66-2.8	0.31-1.4	0.21-2.75	0.02-0.12
Ramparts R.	0.25-0.65	0.10-0.40	0.09-0.14	0.01-0.01
Redknife R.	1.6	0.73	0.67	0.05
Redstone R.	0.78-1.2	0.44-0.77	0.19-0.57	0.02-0.04
Road River	1.1-1.3	0.57-0.66	0.09-0.40	0.02-0.03
Sainville R.	0.50	0.22	0.09	0.01
Saline River	0.56-2.0	0.32-1.4	1.3-23	0.03-0.08
Satah River	0.43	0.18	0.12	<0.01
Secret Creek	0.81	0.38	0.22	0.02
Snake River	1.0	0.61	0.17	0.02
S. Nahanni (Virginia Falls)	0.60-1.3	0.25-0.63	0.03-1.0	0.01-0.02
S. Nahanni (Clausen Creek)	0.54-0.90	0.22-0.45	0.03-0.07	0.01-0.02
Stony Creek	0.18-0.70	0.11-0.30	0.06-0.22	<0.01-0.02
Trail R. (Mackenzie R.)	0.32-1.5	0.13-0.60	0.17-2.7	0.01-0.12
Trail R. (Peel R.)	0.84	0.31	0.08	0.01

Table IIIa	Ca	Mg	Na	K
Trout River	0.57-0.73	0.15-0.24	0.09-0.23	0.02-0.04
Vittrekwa R.	0.63-1.2	0.39-0.89	0.32-0.40	0.01-0.02
Weldon Creek	0.57	0.24	0.25	0.01
Willowlake R.	0.37-2.0	0.08-0.48	0.17-14	0.01-0.15
Wind River	0.99	0.52	0.09	0.01

Table IIIb Ranges of concentrations of total dissolved calcium, magnesium, sodium and potassium measured during 1971-72. Yukon rivers and streams.

	(moles m^{-3})			
LOCATION	Ca	Mg	Na	K
Bell River	0.30-0.68	0.12-0.44	0.11-1.3	0.01-0.03
Bluefish River	0.32-0.98	0.12-0.48	0.02-0.07	0.01-0.02
Caribou Bar Creek	0.01-0.42	<0.01-0.14	0.02-0.10	0.001-0.03
Driftwood River	0.11-0.27	0.09-0.22	0.06-0.15	0.01-0.05
Eagle River	0.68-0.77	0.18-0.22	0.13-0.16	0.01-0.02
Joe Creek	0.02-0.26	0.01-0.17	0.02-0.08	0.01-0.02
Lord Creek	0.29-1.2	0.11-0.18	0.03-0.08	0.01-0.02
Miner River	1.2	0.39	0.15	0.01
Old Crow River	0.09-1.3	0.04-0.34	0.03-0.09	<0.01-0.02
Old Crow Creek	1.3	0.22	0.02	<0.01
Pine Creek	0.29	0.18	0.09	0.01
Porcupine River	0.23-1.5	0.10-0.56	0.03-0.30	0.01-0.03
Summit Lake Outlet	0.69	0.45	1.3	0.03
Timber Creek	1.1	0.21	0.03	0.02

Table IIIc Ranges of concentrations of total dissolved calcium, magnesium, sodium and potassium measured during 1971-72.
Mackenzie Delta channels and sea, rivers and streams.

LOCATION	Ca	Mg	Na	K
	(moles m^{-3})			
Anderson R.	0.47-0.64	0.29-0.46	0.11-0.38	0.02-0.04
Beaufort Sea - 13	2.1-8.0	7.3-40	52-290	1.3-8.7
Beaufort Sea - 15	0.51-2.5	0.33-12	0.80-0.91	0.04-2.4
Beaufort Sea - 24	0.95-1.0	0.23-1.7	0.23-10	0.03-0.29
Beaufort Sea - 26	0.70-3.4	0.42-15	1.3-110	0.07-2.7
Campbell Creek	0.19-0.40	0.10-0.28	0.08-0.17	0.01-0.05
East CH - 1	0.60-1.1	0.26-0.47	0.19-0.46	0.03-0.03
East CH - 3	0.60-1.1	0.26-0.52	0.19-0.47	0.03-0.03
East CH - 4	0.67-1.0	0.29-0.48	0.21-0.49	0.03-0.03
East CH - 7	0.64-1.0	0.28-0.47	0.18-0.49	0.02-0.03
Firth River	1.1-1.3	0.12-0.26	0.04-0.06	0.004-0.004
Gully CH - 1	0.65-0.80	0.28-0.33	0.20-0.20	0.02-0.03
Jamieson CH - 1	0.92	0.47	0.23	0.02
Kugmallit Bay - 4	0.63-3.1	0.34-11	0.27-87	0.02-2.3
Kugmallit Bay - 5	0.78-3.0	0.50-11	0.51-76	0.03-2.0
Kugmallit Bay - 6	0.60-2.7	0.31-11	0.54-91	0.04-2.1
Kugmallit Bay - 8	3.7	16	110	3.4
Main CH - 1	0.68-1.0	0.30-0.46	0.17-0.47	0.02-0.04
Main CH - 3	0.81	0.37	0.26	0.02
Napoiak CH - 1	0.87	0.37	0.23	0.03
Rengleng R.	0.44-0.49	0.25-0.79	0.23-2.0	0.03-0.03

Table IIIc	Ca	Mg	Na	K
West CH - 1	0.71-0.94	0.33-0.53	0.17-0.26	0.02-0.02
West CH - 2	0.72-0.99	0.34-0.54	0.14-0.19	0.02-0.02
West CH - 3	0.95	0.51	0.26	0.02

NOTE: CH = Channel
3 = Station No. 3

Table IIId Ranges of concentrations of total dissolved calcium, magnesium, sodium and potassium measured during 1971-72. Mackenzie Delta lakes.

		(moles m^{-3})		
LOCATION	Ca	Mg	Na	K
Boot Lake	1.4	1.3	0.32	0.04
East Channel L.	0.60-0.86	0.26-0.37	0.17-0.31	0.02-0.03
Shell Lake	0.26-0.50	0.12-0.31	0.10-0.18	0.02-0.05
Lake 1	0.64-1.2	0.27-0.54	0.19-0.54	0.02-0.04
Lake 3	0.46-1.2	0.25-0.53	0.17-0.38	<0.01-0.03
Lake 4	0.44-1.6	0.37-1.1	0.21-0.77	<0.01-0.09
Lake 4C	1.4	1.1	0.75	0.08
Lake C4	0.38-1.4	0.34-0.93	0.18-0.44	<0.01-0.08
Lake 5	0.49-0.86	0.28-0.55	0.16-0.22	0.02-0.05
Lake 7	0.55-0.84	0.26-0.48	0.13-0.22	0.02-0.03
Lake 11	0.55	0.28	0.19	0.03
Lake 12	0.41-0.44	0.21-0.22	0.23-0.26	0.02-0.03

Table IVa Ranges of concentrations of total dissolved sulfate, chloride, bicarbonate nitrogen, phosphorous and silica measured during 1971-72. Mackenzie mainstem rivers and streams.

LOCATION	SO_4 (moles m^{-3})	Cl (moles m^{-3})	HCO_3 (moles m^{-3})	N (mMoles m^{-3})	P (mMoles m^{-3})	Si (mMoles m^{-3})
Arctic Red R.	0.40-0.90	0.00-0.16	1.3-5.0	6.6-65	0.30-2.8	17-56
Blackwater R.	0.15-0.56	0.32-1.1	1.6-2.4	8.2-48	0.43-0.58	17-54
Bluefish R.	1.4	0.12	3.4	120	1.6	76
Brackett R.	0.11-0.29	0.79-2.1	1.3-2.2	8.1-32	0.61-0.94	20-45
Flat River		0.03	1.8	16	1.3	31
Great Bear R. (Great Bear L.)	0.09-0.31	0.11-0.11	0.90-1.1	6.3-11	0.03-5.4	15-35
Great Bear R. (Brackett R.)	0.14-0.15	0.09-0.14	1.0-1.2	9.3-34	0.34-0.50	15-41
Hanna River	0.02-0.12	0.23-0.31	1.8-2.0	13 14	1.5-2.7	19-54
Hare Inidan R.	0.92-2.6	0.00-2.2	1.7-2.8	6.5-40	0.25-0.57	25-63
Harris River	0.27-0.76	<0.01-0.06	0.88-5.2	10-74	0.27-1.1	35-87
Horn River	0.33-0.95	0.89-3.7	0.92-2.6	24-61	0.43-0.88	2.4-57
Jackfish Creek	0.09	0.01	2.7	10	0.53	61
Jean Marie Creek	0.10-0.27	0.01-0.20	1.6-6.0	1.2-54	0.32-1.5	21-130
Johnny Hoe R.	0.21-0.38	0.11-0.13	1.6-2.0	10-21	0.84-1.1	12-38
Liard R. (Fort Liard)	0.18-0.31	<0.01-0.03	1.4-3.3	4.1-44	0.21-3.6	30-100
Liard R. (Mackenzie R.)	0.17-0.38	<0.01-0.12	1.5-3.5	4.9-54	0.31-2.7	23-94
Mackenzie R. (Fort Providence)	0.16-0.23	0.16-0.25	1.4-1.9	5.6-40	0.03-0.71	17-57
Mackenzie R. (Above Liard R.)	0.17-0.35	0.10-0.23	1.5-2.3	5.4-48	0.38-1.2	17-77
Mackenzie R. (Wrigley)	0.55	0.20	1.6	12	0.95	25
Mackenzie R. (Norman Wells)	0.19-0.64	0.06-0.21	1.4-3.1	7.9-40	0.03-1.6	22-63
Mackenzie R. (Fort Good Hope)	0.49	0.17	1.6	15	1.4	25
Mackenzie R. (Arctic Red R.)	0.23-0.39	0.07-0.27	1.8-2.4	9.2-37	0.25-2.2	45-54

Table IVa	SO_4	Cl	HCO_3	N	P	Si
Martin River	0.09-0.20	<0.01-0.20	1.2-5.5	9.2-86	0.32-1.9	31-230
Mosquito Creek	5.4	0.50	3.3	45	0.86	74
Mountain River	0.29-0.86	<0.01-0.09	1.8-3.0	6.2-29	0.41-2.6	17-53
Peel River	0.24-0.64	0.03-0.10	1.4-3.2	5.9-48	0.40-2.4	17-66
Petitot River	0.22-0.51	0.00-0.07	0.70-2.6	15-21	0.61-1.1	24-69
Rabbitskin R.	0.13-0.73	0.01-0.17	1.2-7.8	2.0-103	0.51-1.4	19-160
Redknife R.	0.26	0.14	2.2	33	0.81	140
Redstone R.	0.23-1.0	0.03-0.30	1.6-4.3	7.2-55	0.37-1.9	23-68
Saline River	0.12-8.9	1.6-17	1.2-4.1	11-51	0.30-0.94	25-62
Secret Creek	0.17	<0.01	2.3	53	0.67	63
S. Nahanni (Virginia Falls)	0.16-0.38	<0.01-0.03	1.3-2.8	4.9-38	0.35-1.1	29-85
S. Nahanni (Clausen Creek)	0.17-0.28	<0.00-0.11	1.4-3.2	3.6-14	0.38-2.0	28-62
Trail R. (Mackenzie R.)	0.17-0.31	0.01-3.0	0.76-3.8	5.9-77	0.45-22	61-190
Trout River	0.07-0.15	0.00-0.86	1.4-2.2	11-53	0.34-0.91	3.9-78
Willowlake R.	0.09-0.40	0.09-4.6	0.87-2.7	1.2-63	0.08-1.6	2.4-65

Table IVb Ranges of concentrations of total dissolved sulfate, chloride, bicarbonate, nitrogen, phosphorous and silica measured during 1971-72. Yukon rivers and streams.

	(moles m^{-3})			(mMoles m^{-3})		
LOCATION	SO_4	Cl	HCO_3	N	P	Si
Bell River	0.16-0.44	0.04-1.5	0.16-1.2	29-33	0.30-0.55	19-44
Bluefish R.	0.04-0.08	<0.01-0.03	1.0-3.4	22-41	0.30-1.6	31-62
Caribou Bar Creek	<0.01-0.18	<0.01-0.07	0.12-0.82	15-61	0.15-9.0	3.4-213
Driftwood R.	0.10-0.20	0.01-0.07	0.28-0.60	15-39	0.27-0.61	4.4-62
Eagle River	0.41	<0.01	1.1	45	0.55	61

Table IVb	SO_4	Cl	HCO_3	N	P	Si
Joe Creek	0.04-0.05	<0.01-0.04	0.50-0.98	23-62	0.75-1.1	21-27
Lord Creek	0.09-0.09	<0.01-0.02	0.76-0.77	18-43	0.50-0.61	40-62
Old Crow River	0.05-0.07	<0.01-0.08	0.11-2.5	0.14-52	0.49-9.0	4.0-40
Old Crow Creek			3.2	23	0.26	75
Porcupine River	0.07-0.25	<0.01-0.48	0.63-3.5	0.23-46	0.37-4.3	28-82
Summit Lake Outlet			1.3	37	0.40	23

Table IVc Ranges of concentrations of total dissolved sulfate, chloride, bicarbonate, nitrogen, phosphorus and silica measured during 1971-72. Mackenzie Delta channels and sea, rivers and streams.

		(moles m^{-3})			(Moles m^{-3})	
LOCATION	SO_4	Cl	HCO_3	N	P	Si
Anderson R.	0.14-0.24	0.08-0.28	1.3-1.8	<2.0-42	0.22-1.2	20-41
Beaufort Sea - 13	3.6-20	6.3-84	2.4-2.7	8.8-30	0.22-0.73	16-63
Beaufort Sea - 15	0.21-63	1.0-85	1.3-4.0	15-55	0.23-1.5	26-107
Beaufort Sea - 24	0.23-2.1	0.14-17	2.3-2.9	7.3-27	0.40-0.61	53-96
Beaufort Sea - 26	0.18-11	0.79-140	1.5-2.5	9.7-30	0.27-0.82	31-61
Campbell Creek	0.09-0.22	0.02-0.11	0.20-1.0	29-61	0.49-1.5	4.7-41
East CH - 1	0.14-0.39	0.09-0.43	1.6-2.6	16-38	0.26-1.5	40-67
East CH - 3	0.21-0.40	0.11-0.61	1.5-2.4	17-30	0.22-1.6	46-71
East CH - 4	0.26-0.40	0.12-0.45	1.7-2.4	18-35	0.13-2.1	42-68
East CH - 7	0.24-0.39	0.06-0.42	1.7-2.3	35-82	0.13-0.69	50-64
Firth River	0.10-0.19	<0.01-0.03	2.3-2.7	15-17	0.34-0.49	48
Gully CH - 1	0.22-0.29	0.15-0.16	1.6-1.7	24-41	0.35-0.59	46-50
Jamieson CH - 1	0.27	0.69	1.7	39	0.50	55

Table IVc	SO4	Cl	HCO_3	N	P	Si
Kugmallit Bay - 4	0.23-5.8	0.14-100	1.6-2.2	0.55-31	0.27-1.4	38-67
Kugmallit Bay - 5	0.40-6.2	0.44-100	1.3-2.2	9.8-22	0.36-0.67	36-66
Kugmallit Bay - 6	0.26-6.3	0.49-90	1.5-3.1	16-37	0.55-1.1	34-85
Kugmallit Bay - 8				11	0.37	
Main CH - 1	0.24-0.71	0.06-0.99	1.7-2.5	20-46	0.35-3.9	49-68
Main CH - 3	0.21	0.09	2.2	2.0	8.9	51
Napoiak CH - 1			2.0	7.8	0.41	55
Rengleng R.	0.08-0.13	0.14-1.1	1.3-1.4	39-44	0.45-0.77	25-27
West CH - 1	0.15-0.30	0.06-0.24	1.8-2.2	13-53	0.32-0.97	37-51
West CH - 2	0.28-0.37	0.03-0.08	2.0-2.4	38-39	0.40-0.82	39-50
West CH - 3	0.37	0.70	2.8	27		56

NOTE: CH = Channel
3 = Station No. 3

Table IVd Ranges of concentrations of total dissolved sulfate, chloride, bicarbonate, nitrogen, phosphorus and silica measured during 1971-72. Mackenzie Delta lakes.

	(moles m^{-3})			(mMoles m^{-3})		
LOCATION	SO_4	Cl	HCO_3	N	P	Si
Boot Lake	1.6	<0.01	1.6	16	0.55	40
East Channel L.	0.21-0.28	0.11-0.29	1.5-2.2	19-46	0.49-1.3	39-71
Shell Lake	0.15-0.34	0.02-0.25	0.5-0.9	19-45	0.50-1.3	13-25
Lake 1	0.20-0.56	0.09-0.80	1.6-2.5	1.9-24	0.17-0.83	34-76
Lake 3	0.19-0.43	0.05-0.25	1.4-3.0	2.0-24	0.19-0.56	11-58
Lake 4	0.09-0.25	0.02-0.61	1.6-6.2	4.5-110	0.13-0.87	2.8-90
Lake 4C	0.07	0.83	5.9	21	12	83
Lake C4	0.03-0.21	0.04-0.25	1.2-4.7	13-83	0.45-1.4	2.7-60

Table IVd	SO_4	Cl	HCO_3	N	P	Si
Lake 5	0.20-0.53	0.06-0.20	1.3-2.6	1.2-41	0.48-1.0	3.8-31
Lake 7	0.14-0.31	0.08-0.12	1.3-2.6	0.5-47	0.31-4.6	3.4-25
Lake 11	0.9	0.18	1.2	41	0.59	2.8
Lake 12	0.06-0.07	0.18-0.18	1.1-1.2	43-46	0.41-0.48	3.1-3.6

Table Va Ranges of concentrations of total dissolved iron, manganese, zinc, copper, lead, arsenic, aluminum and cadmium measured during 1971-72. Mackenzie mainstem rivers and streams.

	(mMoles m^{-3})							
LOCATION	Fe	Mn	Zn	Cu	Pb	As	Al	Cd
Arctic Red R.	<0.02-5.4	0.00-0.40	<0.02-0.12	0.02-0.19	<0.01-0.01			<0.01-<0.01
Blackwater R.	1.0-2.0	<1.0-2.0	0.05	0.24	0.01			<0.01-<0.01
Bluefish R.	0.27-4.1	0.00-2.6	0.03-0.11	0.04-1.3	<0.01-0.18			<0.01-0.01
Brackett R.	1.1-4.0	0.00-1.0	<0.02-0.03	0.03-0.06	<0.01-0.01			<0.01-<0.01
Caribou R.	11	1.00						
Cranswick R.	8.0	1.0						
Flat River	3.0	<1.0						
Great Bear R. (Gt. Bear Lake)	<1.0-1.0	<1.0-<1.0		<1.0-<1.0	<1.0	<1.0	<1.0	
Great Bear R. (Brackett River)	0.08-1.1	0.00-1.0	<0.01-0.05	0.09-0.15	0.01-0.01			<0.01-<0.01
Hanna River	11-17	<1.0-1.0						
Hare Indian R.	0.27-3.6	0.00-0.55	<0.02-0.12	0.03-0.08	<0.01-0.02			<0.01-<0.01
Harris River	0.20-5.9	0.00-0.50	0.02-0.25	0.05-0.47	<0.01-0.02			<0.01-0.01
Horn River	1.6-4.6	0.00-0.70	<0.02-0.21	0.04-0.32	0.01-0.02			<0.01-0.02
Hume River	3.0	1.0						

Table Va	Fe	Mn	Zn	Cu	Pb	As	Al	Cd
Jackfish Creek	0.003	<1.0						
Jean Marie Creek	0.00-3.8	0.00-1.3	0.04-0.15	0.04-0.65	<0.01-0.01			<0.01-0.01
Johnny Hoe R.	<1.0-2.0	<1.0-<1.0		<1.0	<1.0	<1.0	<1.0	
Liard R. (Fort Liard)	0.11-6.0	0.00-0.20	<0.02-0.06	0.04-0.25	<0.01-0.01			<0.01-<0.01
Liard R. (Mackenzie R.)	1.1-9.1	0.00-0.50	<0.02-0.84	<0.01-0.72	<0.01-0.01			<0.01-<0.01
Lower Beaver Creek	2.0	<1.0						
Mackenzie R. (Ft. Providence)	0.34-1.5	0.00-2.0	<0.02-0.05	0.03-0.17	<0.01-0.02			<0.01-<0.01
Mackenzie R. (above Liard R.)	0.50-9.8	0.00-0.40	<0.02-0.11	0.06-0.32	<0.01-0.05			<0.01-<0.01
Mackenzie R. (Wrigley)	1.0	<1.0		<1.0	<1.0	<1.0	<1.0	
Mackenzie R. (Norman Wells)	<0.09-12	0.20-0.55	<0.02-0.38	0.04-0.68	0.01-0.02			<0.01-<0.01
Mackenzie R. (Fort Good Hope)	1.0	<1.0		<1.0	<1.0		<1.0	
Mackenzie R. (Arctic Red R.)	0.50-5.2	0.00-<0.20	<0.02-0.09	0.04-0.39	<0.01-0.01			<0.01-0.02
Martin River	<1.0-17	0.00-0.70	0.02-0.19	0.03-0.44	<0.01-0.01			<0.01-<0.01
Mosquito Creek	1.0	<1.0		<1.0				
Mountain River	<0.09-4.0	<1.0-2.0	<0.02-0.08	0.04-0.05	<0.01-0.01			<0.01-<0.01
Ontaratue River	1.0-5.0	<1.0-1.0						
Peel River	0.61-7.0	0.00-1.0	<0.02-0.11	0.02-0.24	<0.01-0.01			<0.01-<0.01
Petitot River	3.0-6.0	<1.0-1.0		<1.0	<1.0	<1.0	<1.0	
Rabbitskin R.	<1.0-7.1	0.00-78	0.05-0.55	<0.03-0.61	<0.01-0.04			<0.01-0.01
Ramparts River	3.0-7.0	1.0-3.0						
Redknife River	<1.0	<1.0		<1.0				
Redstone River	0.00-10	0.00-0.20	<0.02-0.38	0.06-0.66	<0.01-0.01	<1.0	2.0	<0.01-<0.01
Road River	3.0-9.0	1.0-1.0						
Sainville River	10	1.0						

Table Va	Fe	Mn	Zn	Ca	Pb	As	Al	Cd
Saline River	0.30-5.4	0.00-0.40	0.02-0.13	0.05-0.90	0.04-0.20			0.03-0.13
Satah River	3.0	1.0						
Secret Creek	3.0-4.8	<0.20	<0.04	0.09	0.02			<0.01
Snake River	3.0	1.0						
S. Nahanni (Virginia Falls)	0.18-3.0	0.00-<1.0	<0.02-0.02	<0.03-<0.05	<0.01-<0.01	<1.0	1.0	<0.01-0.01
S. Nahanni (Clausen Ck.)	<1.0-3.0	<0.20-<1.0	0.08	0.21-<1.0	0.01-<1.0		1.0	<0.01
Stony Creek	1.0	1.0						
Trail R. (Mackenzie R.)	2.5-14	0.00-0.40	0.05-0.59	<0.03-0.61	<0.01-0.01			<0.01-0.02
Trail R. (Peel R.)	4.6-18	<0.2-1.0	0.06-0.87	0.09-0.54	0.01-0.03			<0.01-0.02
Trout River	0.20-1.4	0.00-0.20	<0.02-0.09	0.03-0.16	<0.01-0.01			<0.01-0.01
Vittrekwa River	2.0-45	1.0-1.0						
Weldon Creek	6.0	1.0						
Willowlake River	1.0-3.9	0.00-0.20	<0.02-0.23	0.03-0.60	0.01-0.29	<1.0	2.0	<0.01-0.08
Wind River	2.0	1.0						

Table Vb Ranges of concentrations of total dissolved iron, manganese, zinc, copper, lead, arsenic, aluminum and cadmium measured during 1971-72. Yukon rivers and streams.

				(mMoles m^{-3})				
LOCATION	Fe	Mn	Zn	Cu	Pb	As	Al	Cd
Bell River	1.7-7.1	0.00-0.00	<0.02-0.14	0.04-0.08	<0.01-0.01			<0.01-<0.01
Bluefish River	2.7-4.1	0.00-0.40	0.03-0.11	0.02-1.3	<0.01-0.18			<0.01-<0.01
Caribou Bar Creek	0.11-8.2	0.00-0.91	0.03-0.84	<0.03-1.1	<0.01-0.68			<0.01-<0.01
Driftwood River	1.9-6.0	0.00-<0.20	0.09-0.18	0.06-0.09	<0.01-0.01			<0.01-<0.01

Table Vb	Fe	Mn	Zn	Cu	Pb	As	Al	Cd
Eagle River	1.4-3.0	0.00-<1.00	0.05	0.06-0.13	<0.01-0.01			<0.01
Joe Creek	11-20	<0.20-0.70	0.04-0.13	0.07-0.22	<0.01-0.08			<0.01-<0.01
Lord Creek	1.0-3.0	0.00-1.0	0.03-0.06	0.06-0.36	<0.01-<0.01			<0.01-<0.01
Miner River	1.0	1.0						
Old Crow River	1.0-9.0	0.00-1.0	0.02-0.25	0.06-0.24	<0.01-0.01			<0.01-<0.01
Old Crow Creek	1.3-4.1	0.20	<0.02	0.04	0.01			<0.01
Pine Creek	8.0	1.0						
Porcupine River	0.72-9.5	0.00-0.40	0.02-0.20	0.02-0.15	<0.01-0.16			<0.01-0.02
Summit Lake Outlet	0.59-1.3	0.00	0.03	0.02	0.01			<0.01
Timber Creek	<1.0	1.0						

Table Vc Ranges of concentrations of total dissolved iron, manganese, zinc, copper, lead, arsenic, aluminum and cadmium measured during 1971-72. Mackenzie Delta channels and sea, rivers and streams.

				(mMoles m^{-3})				
LOCATION	Fe	Mn	Zn	Cu	Pb	As	Al	Cd
Anderson R.	0.68-6.0	0.00-<1.0	<0.02-0.04	0.02-0.04	0.01-0.01	<1.0	1.0	<0.01-<0.01
Beaufort Sea - 13	1.3-4.5	0.00-0.00	0.18-0.73	0.03-0.93	0.02-1.1			0.06-0.47
Beaufort Sea - 15	0.23-16	0.00-0.36	<0.02-0.61	<0.03-0.19	<0.01-0.05			<0.01-0.42
Beaufort Sea - 24	0.20-5.3	0.00-0.18	<0.02-0.08	0.01-0.04	<0.01-0.03			<0.01-0.06
Beaufort Sea - 26	0.40-5.0	0.00-0.18	<0.02-0.26	0.03-0.10	0.01-0.21			<0.01-0.42
Campbell Creek	9.0-32	0.00-6.6	0.02-0.98	<0.03-0.79	<0.01-0.21			<0.01-0.01
East CH - 1	0.20-4.1	0.00-0.20	<0.02-0.09	0.05-0.16	<0.01-0.01			<0.01-<0.01
East CH - 3	0.40-6.3	0.00-1.3	<0.02-0.08	<0.03-0.16	<0.01-0.01			<0.01-<0.01
East CH - 4	0.18-16	0.00-<0.20	<0.02-0.04	0.07-0.37	<0.01-0.01			<0.01-<0.01

Table Vc	Fe	Mn	Zn	Cu	Pb	As	Al	Cd
East CH - 7	0.36-9.8	0.00-0.50	<0.02-0.13	0.07-0.24	<0.01-0.01			<0.01-<0.01
Firth River	0.20-2.2	0.00-0.00	<0.02-0.06	0.03-0.14	0.01-<0.01			<0.01-<0.01
Gully CH - 1	0.84-9.8	0.00-<0.20	<0.02-0.04	0.08-0.23	<0.01-0.01			<0.01-<0.01
Jamieson CH - 1	0.90-2.7	0.00	0.07	0.04	<0.01			<0.01
Kugmallit Bay - 4	0.13-9.1	0.00-0.70	<0.02-0.25	0.03-0.33	0.01-0.39			<0.01-0.37
Kugmallit Bay - 5	0.18-5.0	0.00-0.18	<0.02-0.20	<0.03-0.07	0.01-0.82			<0.01-0.37
Kugmallit Bay - 6	0.17-17	0.00-0.70	<0.02-0.11	0.04-0.40	0.01-0.82			<0.01-0.46
Kugmallit Bay - 8	0.50-3.6	0.18	0.29	0.47	0.03			0.47
Main CH - 1	0.13-11	0.00-0.36	<0.02-0.13	0.05-0.48	<0.01-0.01			<0.01-0.02
Main CH - 3	0.34-1.4	0.00	0.02	0.10	0.01			<0.01
Napoiak CH - 1	0.90-6.8	0.00	0.07	0.16	<0.01			<0.01
Rengleng River	1.3-9.1	0.70-0.90						
West CH - 1	0.90-14	0.00-<0.20	0.02-0.05	<0.03-0.37	<0.01-0.13			<0.01-0.03
West CH - 2	0.40-15	0.00-<0.20	0.02-0.07	0.19-0.31	<0.01-0.01			<0.01-0.01
West CH - 3	0.70-3.4	0.00	0.09	0.09	<0.01			<0.01

Table Vd Ranges of concentrations of total dissolved iron, manganese, zinc, copper, lead, arsenic, aluminum and cadmium measured during 1971-72. Mackenzie Delta lakes.

				(mMoles m^{-3})				
LOCATION	Fe	Mn	Zn	Cu	Pb	As	Al	Cd
Boot Lake	0.20-0.60	0.00	0.16	0.08	0.01			<0.01
East Channel L.	1.1-12	0.00-0.00	0.05-0.07	0.08-0.09	<0.01-<0.01			<0.01-<0.01
Shell Lake	1.6-13	0.00-1.5	0.04-0.43	0.04-0.36	<0.01-0.01			<0.01-<0.01
Lake 1	0.20-12	0.00-<0.20	<0.02-0.12	0.05-0.24	<0.01-0.01			<0.01-0.01

Table Vd	Fe	Mn	Zn	Cu	Pb	As	Al	Cd
Lake 3	0.50-29	0.00-<0.20	0.02-0.09	0.04-0.28	<0.01-<0.01			<0.01-<0.01
Lake 4	0.19-9.6	0.00-18	<0.02-0.92	<0.03-0.65	<0.01-0.73			<0.01-0.04
Lake 4C	4.8	0.37	<0.02	0.08	0.01			<0.01
Lake C4	0.70-7.3	0.00-14	<0.02-0.08	<0.03-0.27	<0.01-0.05			<0.01-<0.01
Lake 5	0.17-29	0.00-1.1	0.04-0.07	0.03-0.20	<0.01-<0.01			<0.01-<0.01
Lake 7	0.27-5.4	0.00-1.5	0.07-0.13	0.08-0.18	<0.01-<0.01			<0.01-<0.01
Lake 11	1.4	0.20	0.04	0.30	0.01			<0.01
Lake 12	0.20-1.8	0.00-0.50	0.09-0.16	0.10-0.59	0.01-0.04			<0.01-0.01

Table VIa Ranges of concentrations of total suspended sediment, ranges of Secchi visibility, colours at half Secchi depth, and ranges of percent by weight of suspended constituents lost upon ignition at 500°C measured during 1971-72; major mineral Mackenzie mainstem rivers and streams.

LOCATION	Suspended Sediment (grams m^{-3})	Secchi Depth (m)	Secchi Colour	Major minerals	% L.O.I.
Arctic Red R.	0.79-790	0.08-0.28	Brown, Grey, Rust, Red	1. Quartz 2. Calcite 3. Dolomite 4. Plagioclase 5. Illite 6. Chlorite	5.8-13
Blackwater R.	0.52-47	>1->1.2	Orange, Red		
Bluefish R.	6.3				
Brackett R.	16-33	0.4-0.6	Tan, Olive, Brown	1. Quartz	
Caribou R.		0.06-0.10			
Cranswick R.		0.23			
Flat River	345	0.05		1. Quartz 2. Calcite 3. Chlorite 4. Dolomite 5. Plagioclase 6. Illite	9.7

Table VIa	Suspended Sediment	Secchi Depth	Colour	Major minerals	L.O.I.
Great Bear R. (Gt. Bear L.)	0.02-0.25	>4.0->4.0			
Great Bear R. (Brackett R.)	2.3-6.8	2.2->2.0	Green, White		
Hanna River	180-2100	0.09		1. Quartz 2. Dolomite 3. Calcite 4. Chlorite 5. Plagioclase 6. Illite	8.1
Hare Indian R.	<0.5-99	1.3-∿2.0	Yellow, Green Orange, Brown		
Harris River	<0.20-5.6	0.56->1.0	Red, Brown		
Horn River	0.68-24	∿0.3->2.1	Orange, Brown		
Hume River		0.23			
Jackfish Creek	6.2	>0.3	"Humic"		
Jean Marie Creek	<0.20-4.3	0.61->1.0	Red, Brown		
Johnny Hoe River	1.5-3.2	>1.3->1.5			
Liard R. (Fort Liard)	3.3-560	0.06-0.28	Gray, Green Brown	1. Quartz 2. Dolomite 3. Calcite 4. Chlorite 5. Illite 6. Plagioclase	6.7-10
Liard R. (Mackenzie R.)	0.36-1100	<0.02-0.60	Gray, Green Brown	1. Quartz 2. Dolomite 3. Calcite 4. Chlorite 5. Illite 6. Plagioclase	3.9-10
Mackenzie R. (Ft. Providence)	2.3-7.5	0.50->1.0	Gray, Green		
Mackenzie R. (above Liard R.)	7.7-230	0.23-1.0	Gray, Green Brown	1. Quartz 2. Dolomite 3. Chlorite 4. Illite 5. Calcite 6. Plagioclase	
Mackenzie R. (Wrigley)	62	0.38		1. Quartz 2. Dolomite 3. Calcite 4. Plagioclase	
Mackenzie R. (Norman Wells)	3.5-1800	0.07-0.40	Green, Brown	1. Quartz 2. Dolomite 3. Calcite 4. Chlorite 5. Illite 6. Plagioclase	12-16
Mackenzie R. (Ft. Good Hope)	190	0.12		1. Quartz 2. Dolomite 3. Calcite 4. Chlorite 5. Plagioclase 6. Illite	

Table VIa	Suspended Sediment	Secchi Depth	Colour	Major minerals	L.O.I.
Mackenzie R. (Arctic Red R.)	65-1400	0.02-0.17	Gray, Brown	1. Quartz 2. Dolomite 3. Calcite 4. Plagioclase 5. Chlorite 6. Illite	5.8-15
Martin River	0.41-120	0.23->1.0	Red, Brown, Gray, Yellow, Green		
Mosquito Creek	0.97				
Mountain R.	1.5-2000	0.05		1. Dolomite 2. Quartz 3. Calcite 4. Plagioclase 5. Chlorite 6. Illite	12
Ontaratue R.		>1.0			
Peel River	0.24-580	<0.05-0.23	Gray, Brown	1. Quartz 2. Dolomite 3. Chlorite 4. Calcite 5. Plagioclase 6. Illite	6.1-28
Petitot R.	12-150	0.35-~1.5	Orange, Brown	1. Quartz 2. Dolomite 3. Calcite 4. Chlorite 5. Illite 6. Plagioclase	
Rabbitskin R.	0.80-24	0.38-~1.5	Red, Brown Green		
Ramparts River		0.15			
Redknife River	0.26				
Redstone River	39-1400	<0.02-0.28	Gray, Brown	1. Quartz 2. Dolomite 3. Calcite 4. Chlorite 5. Illite 6. Plagioclase	10-13
Road River		0.05-0.08			
Sainville R.		0.11-0.17			
Saline River	0.81-270	~0.10->2.0	Yellow, Orange	1. Dolomite 2. Quartz 3. Plagioclase 4. Chlorite 5. Illite 6. Calcite	14
Secret Creek	7.5	>1.0	Red, Brown		
S. Nahanni (Virginia Falls)	0.66-200	0.15-1.1	Gray, Green	1. Calcite 2. Dolomite 3.Quartz 4. Illite 5. Chlorite 6. Plagioclase	19

Table VIa	Suspended Sediment	Secchi Depth	Colour	Major minerals	L.O.I.
S. Nahanni (Clausen Creek)	18-500	∿0.10-0.80	Gray, Green	1. Dolomite 2. Calcite 3. Quartz 4. Plagioclase 5. Chlorite 6. Illite	
Stony Creek		0.22			
Trail R. (Mackenzie R.)	0.91-55	0.49->1.0	Red, Brown		
Trout River	0.72-12	∿0.4->1.5	Yellow, Green Brown		
Vittrekwa R.		0.06-0.08			
Weldon Creek		0.23-0.67			
Willowlake R.	1.3-100	0.52->1.5	Orange, Red Brown	1. Plagioclase 2. Quartz	
Wind River		0.36			

Table VIb Ranges of concentrations of total suspended sediment, ranges of Secchi visibility, colours at half Secchi depth, and ranges of percent by weight of suspended sediment lost upon ignition at 500°C measured during 1971-72; major mineral constituents of the suspended sediment detected during 1971-72. Yukon rivers and streams.

LOCATION	Suspended Sediment	Secchi Depth (m)	Colour	Major minerals	% L.O.I.
Bell River	2.3-36	0.15->0.60	Gray, Green		
Bluefish River	0.56-100	0.10->0.90	Orange, Green		
Caribou Bar Creek	0.13-760	0.22->1.0	Yellow, Orange Gray, Brown		
Driftwood R.	0.40-2.7	>1.2			
Eagle River	2.4	0.79	Brown		
Joe Creek	2.5-140	0.20- 1.2	Yellow, Orange Brown		

Table VIb	Suspended Sediment	Secchi Depth	Colour	Major minerals	L.O.I.
Lord Creek	2.2	>0.56->1.5	Yellow, Brown		
Old Crow River	2.1-610	0.22-0.75	Yellow, Brown	1. Quartz 2. Plagioclase 3. Dolomite 4. Chlorite 5. Calcite	8.3
Old Crow Creek	<0.20	>0.10			
Porcupine River	8.5-92	0.20-1.1	Yellow, Brown		
Summit Lake Outlet	1.0				
Timber Creek		0.30			

Table VIc Ranges of concentrations of total suspended sediment, ranges of Secchi visibility, colours at half Secchi depth, and ranges of percent by weight of suspended sediment lost upon ignition at 500°C measured during 1971-72; major mineral constituents of the suspended sediment detected during 1971-72. Mackenzie Delta channels and sea, rivers and streams.

LOCATION	Suspended Sediment (grams m^{-3})	Secchi Depth (m)	Colour	Major minerals	% L.O.I.
Anderson R.	1.5-340	0.15-1.2	Brown, Yellow	1. Dolomite 2. Quartz 3. Chlorite 4. Plagioclase 5. Illite	
Beaufort Sea - 13	3.3-8.0	2.5			
Beaufort Sea - 15	6.0-350	0.05-0.15		1. Dolomite 2. Quartz 3. Chlorite 4. Illite 5. Plagioclase 6. Calcite	13
Beaufort Sea - 24	2.0-920	0.05-0.10		1. Quartz 2. Dolomite 3. Calcite 4. Chlorite 5. Illite 6. Plagioclase	8.5-13
Beaufort Sea - 26	26-450	0.07-0.30		1. Quartz 2. Calcite 3. Dolomite 4. Chlorite 5. Plagioclase 6. Illite	12

Table VIc	Suspended Sediment	Secchi Depth	Colour	Major minerals	L.O.I.
Blow River		<0.05			
Campbell Creek	2.4-28	0.75-2.0			
East CH - 1	<0.33-450	0.04-0.27			14
East CH - 3	0.60-730	0.02-0.30		1. Quartz 2. Calcite 3. Dolomite 4. Chlorite 5. Illite 6. Plagioclase	13
East CH - 4	0.90-660	0.02-0.15		1. Calcite 2. Dolomite 3. Quartz 4. Chlorite 5. Plagioclase 6. Illite	
East CH - 7	0.59-540	0.01-0.16		1. Quartz 2. Calcite 3. Dolomite 4. Chlorite 5. Illite 6. Plagioclase	14
Firth River	4.0-12	>2.8			
Gully CH - 1	12-140	0.12-0.22			
Jamieson CH - 1	130	0.04			
Kugmallit Bay - 4	1.6-370	0.05-0.18		1. Quartz 2. Dolomite 3. Calcite 4. Chlorite 5. Illite 6. Plagioclase	5.6-12
Kugmallit Bay - 5	<0.33-30	0.22-0.23			
Kugmallit Bay - 6	98-340	0.08			
Kugmallit Bay - 8	320	0.10		1. Quartz 2. Dolomite 3. Chlorite 4. Illite 5. Calcite 6. Plagioclase	
Main CH - 1	0.31-1000	0.02-0.06		1. Quartz 2. Dolomite 3. Calcite 4. Illite 5. Chlorite 6. Plagioclase	14
Main CH - 3	170	0.20			
Napoiak CH - 1	123				
Rengleng River	4-5				

Table VIc	Suspended Sediment	Secchi Depth	Colour	Major minerals	L.O.I.
West CH - 1	100-450	0.02-0.08			12-15
West CH - 2	58-190	0.04-0.07			16
West CH - 3	87	0.13			

NOTE: CH = Channel
3 = Station No. 3

Table VId Ranges of concentrations of total suspended sediment, ranges of Secchi visibility, colours at half Secchi depth and ranges of percent by weight of suspended sediment lost upon ignition at 500°C measured during 1971-72; major mineral constituents of the suspended sediment detected during 1971-72. Mackenzie Delta lakes.

LOCATION	Suspended Sediment (grams m^{-3})	Secchi Depth (m)	Colour	Major minerals	% L.O.I.
Boot Lake	4.6	0.85			
East Channel L.	18-210	0.02-0.35			
Shell Lake	0.55-25	1.8->2.0			
Lake 1	3.9-110	0.11-0.15			
Lake 3	4-110	0.13-0.27			
Lake 4	0.89-52	0.70->2.0			
Lake 4C	22				
Lake C4	1.3-600	0.70-1.3			
Lake 5	1.4-100	0.17-1.6			
Lake 7	1.7-44	0.18-1.7			
Lake 11	0.73	2.5			
Lake 12	1.3-2.0	3.7-3.9			

Table VIIa Ranges of concentrations of total suspended carbon, nitrogen and phosphorous and mean molar ratio of suspended carbon to suspended nitrogen measured during 1971-72 (separation of suspended sediment from solution and measurement of C, N and P carried out on a glass fibre filter). Mackenzie mainstem rivers and streams.

LOCATION	C	N (mMoles m^{-3})	P	mean molar ratio C/N
Arctic Red R.	67-1600	4.4-73	0.35-4.2	13
Blackwater R.	15-170	0.87-8.2	0.07-1.5	18
Bluefish R.	100	15	1.4	7.1
Brackett R.	89-140	6.3-11	0.63-1.1	14
Flat River	990	74	7.1	13
Great Bear R. (Great Bear Lake)	12-100	3.6-4.5	0.10-0.58	13
Great Bear R. (Brackett River)	31-97	2.0-9.2	0.13-0.46	17
Hanna River	500-5100	34-270	3.2-56	17
Hare Indian R.	15-160	1.0-13	0.10-0.90	18
Harris River	7.9-140	0.68-21	0.05-0.90	17
Horn River	20-160	1.8-11	0.15-1.0	14
Jackfish Creek	37	1.6	0.16	24
Jean Marie Creek	18-150	1.1-18	0.16-0.70	16
Johnny Hoe R.	36	2.5	0.16	15
Liard R. (Fort Liard)	3.3-690	0.27-45	0.92-6.9	16
Liard R. (Mackenzie R.)	64-2200	2.2-110	0.26-24	20
Mackenzie R. (Fort Providence)	28-190	1.8-14	0.18-0.93	12
Mackenzie R. (above Liard R.)	49-810	2.8-14	0.17-6.6	13
Mackenzie R. (Wrigley)	230	4.4	1.3	53

Table VIIa	C	N	P	C/N
Mackenzie R. (Norman Wells)	62-6300	3.5-180	0.70-27	26
Mackenzie R. (Fort Good Hope)	520	8.4	2.5	62
Mackenzie R. (Arctic Red River)	210-510	13->57	0.73-6.6	21
Martin River	21-160	1.2-20	0.13-1.8	13
Mosquito Creek	20	1.4	0.07	14
Mountain River	61-5100	2.7-130	2.1-25	35
Peel River	36-920	2.3-51	0.50-4.9	16
Petitot R.	56-89	3.7-6.2	0.52-2.3	15
Rabbitskin R.	20-190	1.6-12	0.19-1.1	14
Redknife River	19	1.0	0.10	18
Redstone R.	31-2700	4.0-110	0.60-16	20
Saline River	13-650	0.64-16	0.07-3.5	24
Secret Creek	84	7.8	0.60	11
S. Nahanni (Virginia Falls)	21-260	0.82-28	0.19-2.0	31
S. Nahanni (Clausen Creek)	24-1100	4.2-32	0.29-6.4	26
Trail R. (Mackenzie R.)	45-280	2.9-49	0.08-1.3	14
Trout River	5.4-130	0.17-12	0.03-0.77	18
Willowlake R.	53-250	3.5-13	0.22-2.0	14

Table VIIb Ranges of concentrations of total suspended carbon, nitrogen and phosphorous and mean molar ratio of suspended carbon to suspended nitrogen measured during 1971-72 (separation of suspended sediment from solution and measurement of C, N and P carried out on a glass fibre filter).
Yukon rivers and streams.

LOCATION	C (mMoles m^{-3})	N (mMoles m^{-3})	P (mMoles m^{-3})	mean molar ratio C/N
Bell River	93-300	13-38	0.75-1.9	7.0
Bluefish R.	69->330	6.7-31	0.20-1.9	12
Caribou Bar Creek	37-180	3.1-23	0.14-1.3	20
Driftwood R.	63-103	8.0-17	0.20-0.49	11
Eagle River	83	8.9	0.37	9.3
Joe Creek	110-440	8.9-36	0.67-2.9	12
Lord Creek	51-57	6.3-6.3	0.16-0.33	8.6
Old Crow River	79-1400	8.8-97	0.29-6.0	11
Old Crow Creek	58	5.4	0.29	11
Porcupine R.	64-210	7.8-18	0.72-2.5	25
Summit Lake Outlet	230	39	0.73	5.9

Table VIIc Ranges of concentrations of total suspended carbon, nitrogen and phosphorous and mean molar ratio of suspended carbon to suspended nitrogen measured during 1971-72 (separation of suspended sediment from solution and measurement of C, N and P carried out on a glass fibre filter). Mackenzie Delta channels and sea, rivers and streams.

LOCATION	C (mMoles m^{-3})	N (mMoles m^{-3})	P (mMoles m^{-3})	mean molar ratio C/N
Anderson R.	69-610	7.4-29	0.11-3.9	13
Beaufort Sea - 13		7.3	1.1	
Beaufort Sea - 15	63-640	2.5-34	0.23-3.0	23
Beaufort Sea - 24	75-760	4.2-61	0.26-3.9	17
Beaufort Sea - 26	76-1100	2.4-51	0.29-3.4	29
Campbell Creek	61-480	3.4-31	0.28-2.7	14
East CH - 1	110-610	5.4-29	0.29-2.6	18
East CH - 3	110-950	2.5-55	0.26-2.9	24
East CH - 4	90-480	2.6-28	0.23-3.1	27
East CH - 7	58-730	19-53	2.7-3.3	8.5
Firth River	100	5.6	0.25-0.60	19
Gully CH - 1	340	19	0.62-2.3	18
Jamieson CH - 1	260	15	2.7	18
Kugmallit Bay - 4	58-640	2.9-36	0.21-3.4	16
Kugmallit Bay - 5	120-140	7.7-13	0.90-1.1	13
Kugmallit Bay - 6	140-340	13-17	1.6-2.3	14
Kugmallit Bay - 8	71	4.4	0.26	16
Main CH - 1	130-1600	4.2-74	0.39-3.7	24
Main CH - 3	400	21	1.9	19

Table VIIc	C	N	P	C/N
Napoiak CH - 1	280	12	1.4	36
Rengleng River	100-140	2.6-5.9	0.26-0.32	25
West CH - 1	130-270	9.9-26	2.1-2.2	14
West CH - 2	240-410	14-24	2.3-2.9	17
West CH - 3	230	13	1.9	18

NOTE: CH = Channel
3 = Station No. 3

Table VIId Ranges of concentrations of total suspended carbon, nitrogen and phosphorous and mean molar ratio of suspended carbon to suspended nitrogen measured during 1971-72 (separation of suspended sediment from solution and measurement of C, N, and P carried out on a glass fibre filter).
Mackenzie Delta lakes.

LOCATION	C	(mMoles m^{-3}) N	P	C/N
Boot Lake	100	8.4	0.82	12
East Channel L.	110-300	4.6-16	0.45-2.0	19
Shell Lake	110-380	5.2-43	0.39-2.6	14
Lake 1	90-280	4.9-15	0.48-2.5	15
Lake 3	96-190	4.3-11	0.42-1.6	17
Lake 4	72-390	3.1-25	0.25-33	17
Lake 4C	180-740	8.1-32		25
Lake C4	49-400	2.4-23	0.19-1.7	17
Lake 5	88-160	3.8-23	0.34-1.8	13
Lake 7	99-130	5.6-12	0.23-1.0	13
Lake 11			0.75	
Lake 12	58-130	8.6-12	0.37-0.41	8.9

Table VIIIa Ranges of concentrations of total suspended carbon, nitrogen and phosphorous and of carbonate (inorganic) carbon measured during 1971-72 (separation of suspended sediment from solution by centrifugation). Mackenzie mainstem rivers and streams.

	(mMoles m^{-3})			
LOCATION	C	CO_3-C	N	P
Arctic Red R.	130-1100	21-950	0.85-68	0.78-8.4
Blackwater R.	200	190	7.4	0.94
Flat River		3100		
Hanna River		9.4		
Horn River	100		8.8	
Liard R. (Fort Liard)	510-1350	300-1300	18-52	2.9-10
Liard R. (Mackenzie R.)	270-2800	180-2500	16-110	4.9-25
Mackenzie R. (Norman Wells)	500-3100	390-2600	16-89	2.5-9.9
Mackenzie R. (Arctic Red R.)	110-4900	120-2800	6.5-140	0.91-42
Martin River	160	82	8.9	
Mountain R.	410	380-23000	12	2.4
Peel River	27-400	36-330	3.0-29	1.5-6.0
Rabbitskin R.	66	40	3.9	
Redstone R.	470-3800	1500-6000	25-120	6.5-17
Saline River	870	700	17	
S. Nahanni (Virginia Falls)	950-980	780-870	11-23	
Trail River	130		4.9	
Trout River	2.7	2.1	0.16	
Willowlake R.	310	300	12	2.0

Table VIIIb Ranges of concentrations of total suspended carbon, nitrogen and phosphorous and of carbonate (inorganic) carbon measured during 1971-72 (separation of suspended sediment from solution by centrifugation). Yukon rivers and streams.

	(mMoles m^{-3})			
LOCATION	C	CO_3-C	N	P
Bluefish R.	540	350	21	1.2
Caribou Bar Creek	21	18	1.7	
Joe Creek	400	98	24	3.4
Old Crow River	130-1200	19-580	8.0-70	1.1-2.3
Porcupine R.	220	29	3.7	2.1

Table VIIIc Ranges of concentrations of total suspended carbon, nitrogen and phosphorous and of carbonate (inorganic) carbon measured during 1971-72 (separation of suspended sediment from solution by centrifugation). Mackenzie Delta channels and sea, rivers and streams.

	(mMoles m^{-3})			
LOCATION	C	CO_3-C	N	P
Beaufort Sea - 15	110-770	6.9-380	9.3-35	3.1-8.1
Beaufort Sea - 24	1500-3200	160-760	66-170	13-13
Beaufort Sea - 26	260-920	130-440	26-45	2.5-10
Campbell Creek	84-110	20	5.9-9.3	
East CH - 1	840-1400	130-720	35-39	11
East CH - 3	2100	1700	66	10
East CH - 4	280-1800	44-1200	13-59	1.7-25
East CH - 7	940-1600	560-1200	42-48	7.1-11

Table VIIIc	C	CO_3-C	N	P
Firth River	14.8	7.7	0.48	
Gully CH - 1	300	250	13	
Jamieson CH - 1	120	120	12	4.9
Kugmallit Bay - 4	290-770	96-640	15-37	4.0-6.8
Kugmallit Bay - 6	410-700	0.00-550	20-39	3.6-6.4
Kugmallit Bay - 8	930	390	45	9.9
Main CH - 1	410-3200	240-2900	24-83	5.6
Main CH - 3	750	150	32	4.3
West CH - 1	540-1100	310-570	29-52	7.3
West CH - 2	490-570	240-330	26-32	

Table VIIId Ranges of concentrations of total suspended carbon, nitrogen and phosphorous and of carbonate (inorganic) carbon measured during 1971-72 (separation of suspended sediment from solution by centrifugation). Mackenzie Delta lakes.

		(mMoles m^{-3})		
LOCATION	C	CO_3-C	N	P
Shell Lake	290-710	46-52	26-62	
Lake 1	190		14	
Lake 3	220-240	100-100	16-18	1.5-3.7
Lake 4	77-350	25-130	5.5-19	0.55
Lake C4	62-7500	45-1800	4.2-410	
Lake 5	110-240	47	13-19	2.6
Lake 7	120		10	

Table IXa Ranges of concentrations of total suspended calcium, potassium, silica, aluminum, titanium, iron and manganese measured during 1971-72 (separation of suspended sediment from solution by centrifugation). Mackenzie mainstem rivers and streams.

LOCATION	Ca	K	(mMoles m^{-3}) Si	Al	Ti	Fe	Mn
Arctic Red R.	330-410	130-350	1900-6000	540-1700	18-53	160-510	2.4-5.9
Flat River	570	210	3500	1100	31	280	2.1
Hanna River	1100	1200	23000	7000	210	1800	23
Liard R. (Fort Liard)	190-1000	100-200	1900-2700	430-810	13-20	86-190	2.2-3.7
Liard R. (Mackenzie R.)	240-1000	140-580	3000-11000	700-3000	23-82	190-630	3.2-11
Mackenzie R. (Norman Wells)	320-1500	120-440	1900-6800	530-2000	17-60	150-500	2.3-9.3
Mackenzie R. (Arctic Red R.)	700-2800	330-790	5400-11000	1600-3500	45-100	410-900	5.9-18
Mountain R.	3200	1100	21000	4900	180	1500	22
Peel River	40-290	43-290	770-6200	220-1500	7.0-52	45-440	0.88-6.4
Redstone R.	750-1800	350-780	5300-12000	1700-3700	52-110	480-1000	5.8-19
S. Nahanni (Virginia Falls)	540	100	1400	420	11	980	2.2

Table IXc Ranges of concentrations of total suspended calcium, potassium, silica, aluminum, titanium, iron and manganese measured during 1971-72 (separation of suspended sediment from solution by centrifugation). Mackenzie Delta channels and sea, rivers and streams.

LOCATION	Ca	K	Si (mMoles m^{-3})	Al	Ti	Fe	Mn
Beaufort Sea - 24	610-1100	400-570	5300-7900	1900-2800	52-79	500-670	7.6-12
East CH - 4	1000	400	5400	2000	52	480	6.5
East CH - 7	420	270	3200	1300	30	310	3.7
Main CH - 1	1500	640	8800	2800	75	730	12
West CH - 1	340	230	4500	1100	35	290	5.1

Table X Some chemical and physical characteristics of the East Channel (EC1), Main Channel (MC1), and West Channel (WC1) of the Mackenzie River Delta for 1972.

Location	Date	(°C) Temp	(moles m^{-3}) O_2	(μmho cm^{-1}) Field Cond	pH	Ca	Mg	Na	K	HCO_3	SO_4	Cl
EC1	March 14/72	0.0	.16	150	7.6	1.05	.473	.457	.032	2.20	.394	.403
EC1	June 12/72	7.6	.16	300	7.65	.600	.260	.186	.027	1.60	.143	.090
EC1	July 30/72	15.7	.29	500	7.9					1.93	.230	.425
EC1	Sept. 27/72		.38	265	7.75	.835	.374	.330	.026	1.93	.278	.208
WC1	March 17/72	Ice to bottom										
WC1	July 9/72	15.2	.30	380	7.75	.715	.329	.166	.024	1.79	.153	.113
WC1	Aug. 15/72	13.2	.33	320	7.5	.938	.534	.262	.019	2.16	.303	.062
MC1	March 19/72	0.0	.18	150	7.7	.970	.457	.470	.032	2.10	.381	.462
MC1	June 29/72	11.9	.31	300	7.7	.680	.302	.195	.024	1.74	.241	.059
MC1	Aug. 14/72	14.8	.30		7.4	.900	.370	.237	.028	2.21	.261	.152

Location	Date	TDP	PP	(mMoles m^{-3}) TDN	PN	dSi	PC	(mg l^{-1}) +S.S.	(m) Secchi
EC1	March 14/72	0.67		16.0		67.0		<0.33	
EC1	June 12/72	0.97	2.26	38.3	29.3	40.3		447	0.05
EC1	July 30/72	0.55	2.64	24.6	28.5	53.5	607	362	0.04
EC1	Sept. 27/72	0.26	1.01	19.5	7.14	60.4	151	34.6	0.27
WC1	March 17/72	0.97	2.21	37.7	26.0	37.4	133	221	0.08
WC1	July 9/72	0.72	2.08	53.0	23.1	37.1	273	452	0.08
WC1	Aug. 15/72	0.32	2.17	13.1	9.93	51.1	261	99.6	0.02
MC1	March 19/72	0.45		32.0		64.2		2.65	
MC1	June 29/72	0.59	3.65	36.7	66.0	49.4	1220	1047	0.02
MC1	Aug. 14/72	0.73	2.63	45.6	32.4	56.7	542	199	0.06

+S.S. = suspended sediment

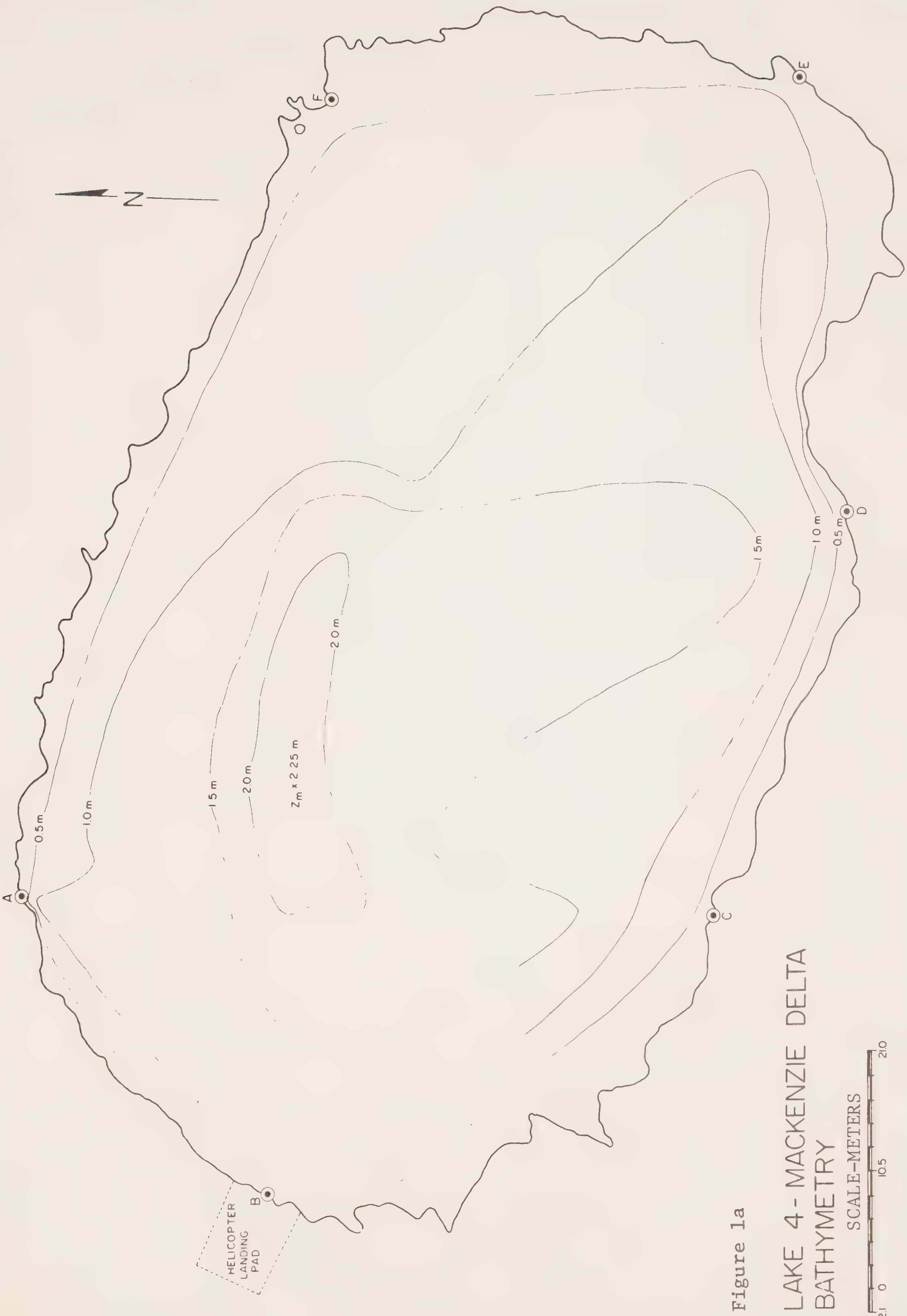


Figure 1a

LAKE 4 - MACKENZIE DELTA
BATHYMETRY
SCALE-METERS

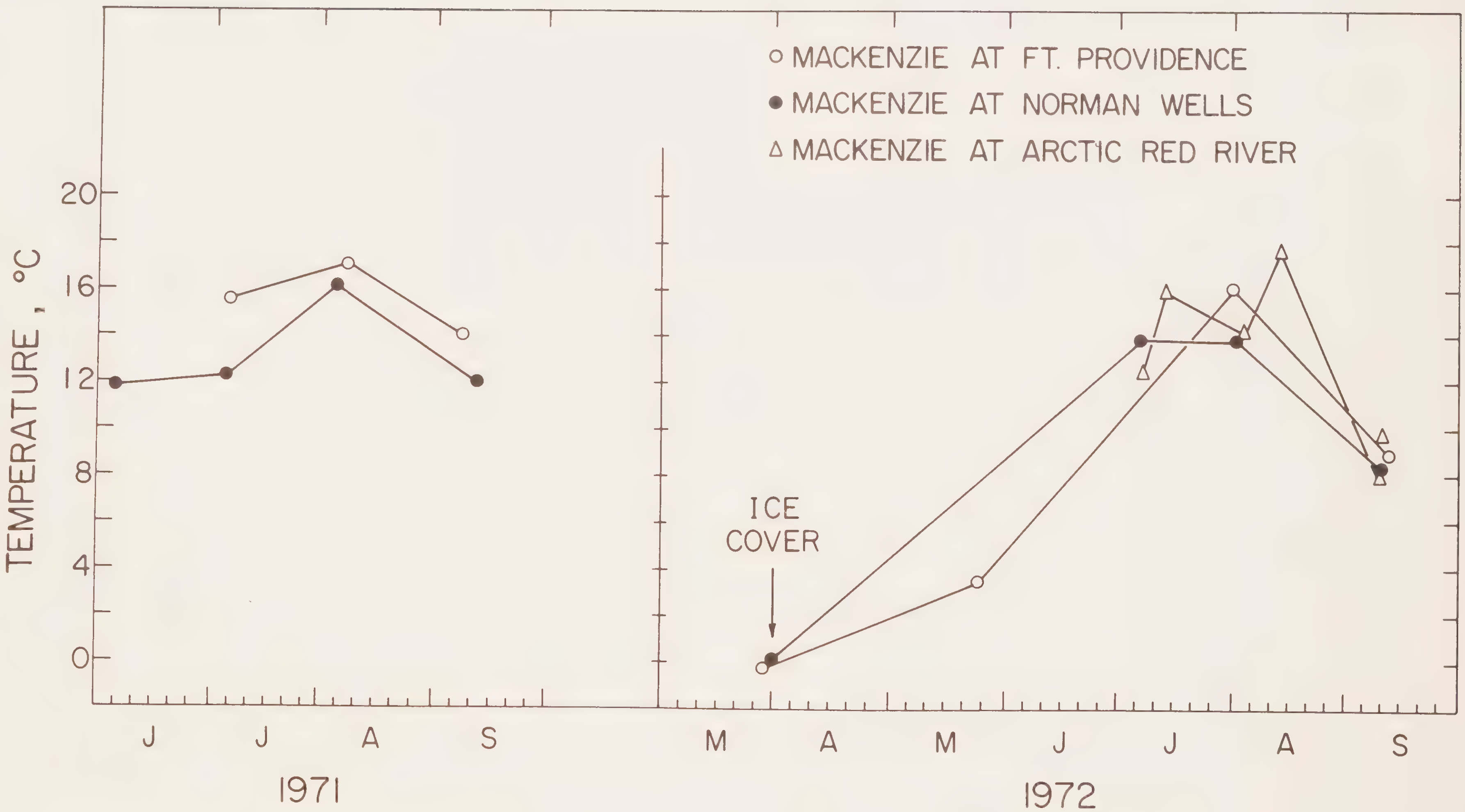


Figure 2a. Seasonal variation of water temperature. Mackenzie River at Fort Providence, Mackenzie River at Norman Wells and Mackenzie River at Arctic Red River (1971-72).

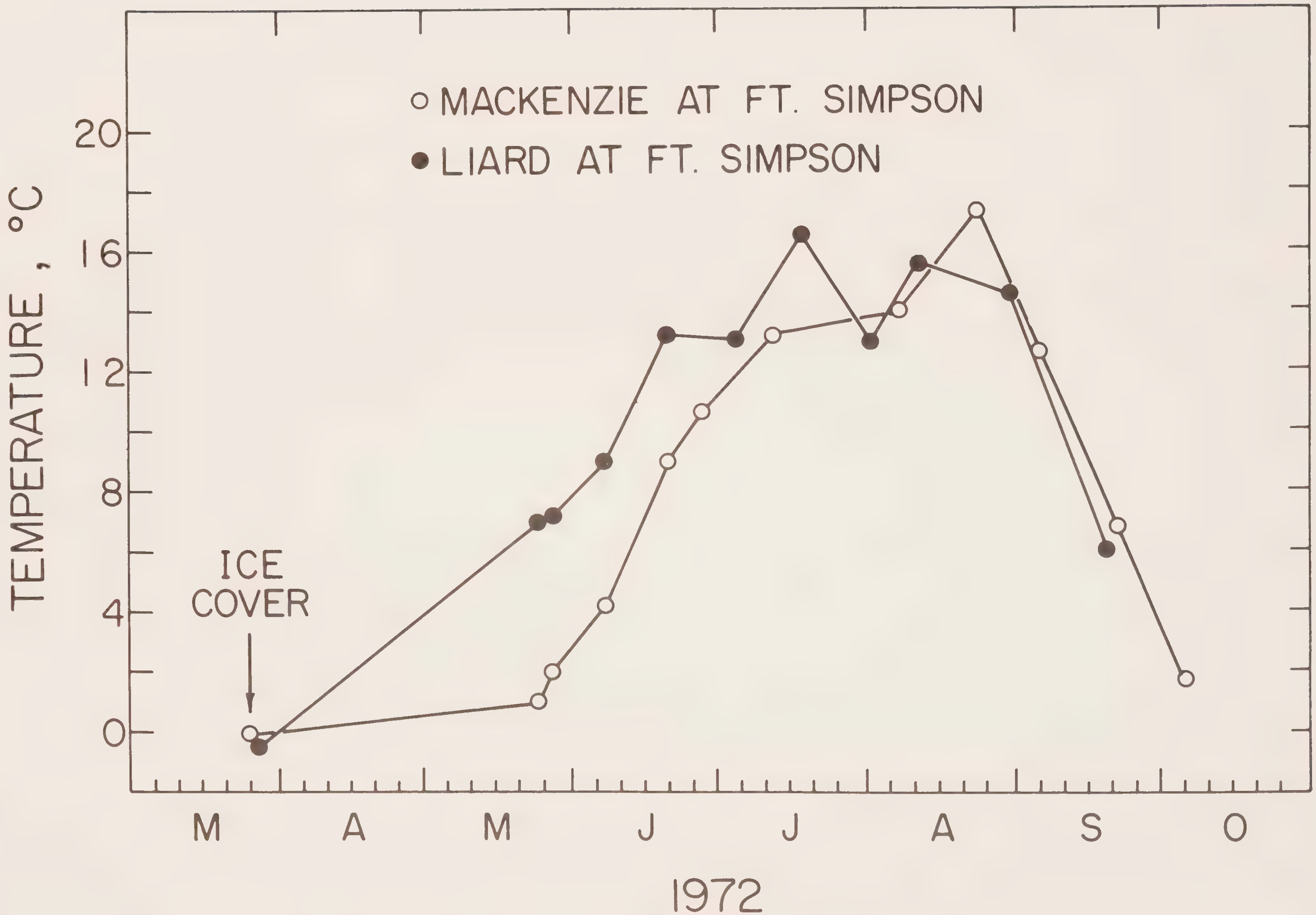


Figure 2b. Seasonal variation of water temperature. Mackenzie River above Fort Simpson and Liard River at Fort Simpson (1972).

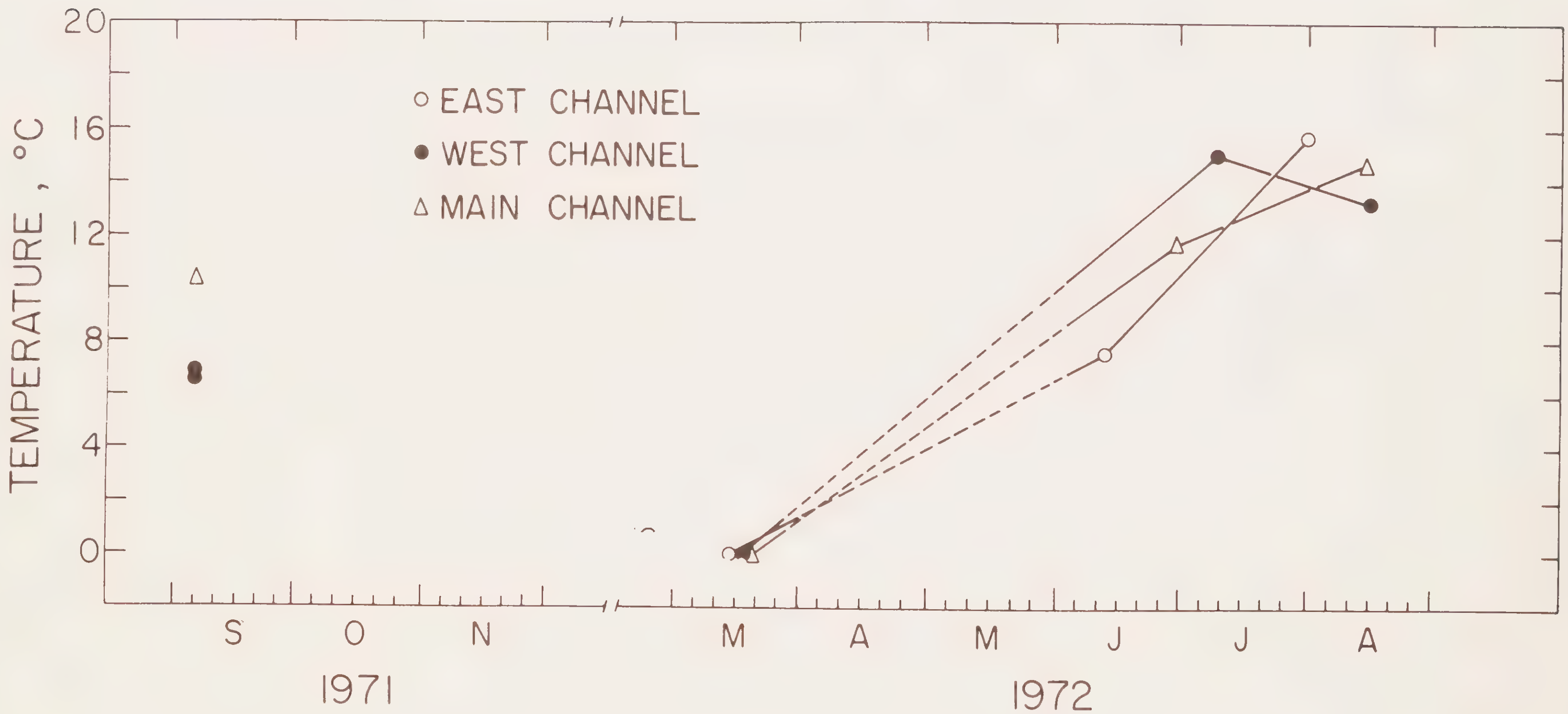


Figure 2c. Seasonal variation of water temperature. East Channel - EC1, West Channel - WC1, and Main Channel - MC1, (1971-72).

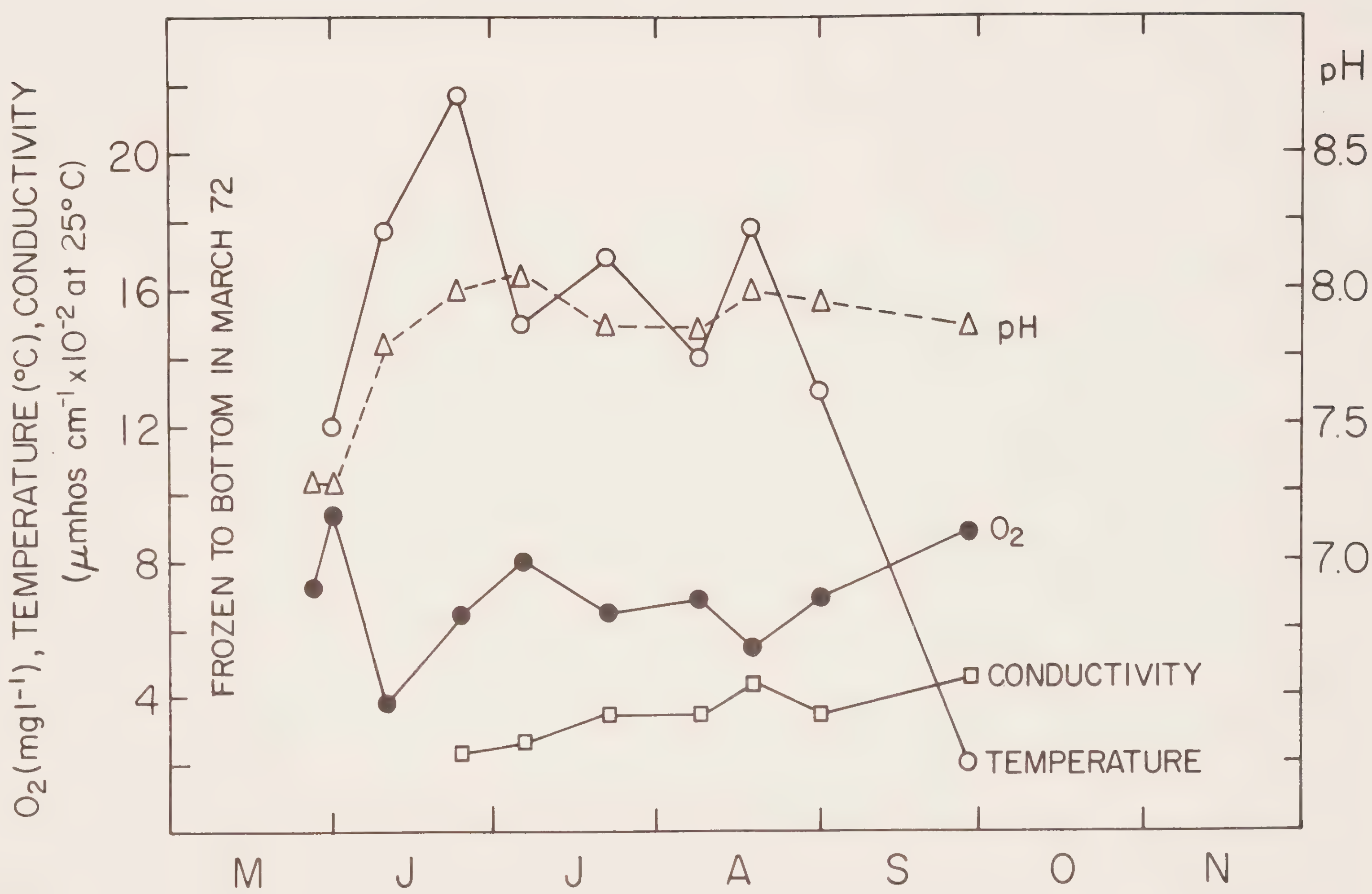


Figure 3a. Seasonal variation of water temperature, dissolved oxygen (O_2), pH and specific conductance at 25°C (cond.). Harris River at Mackenzie River (1972).

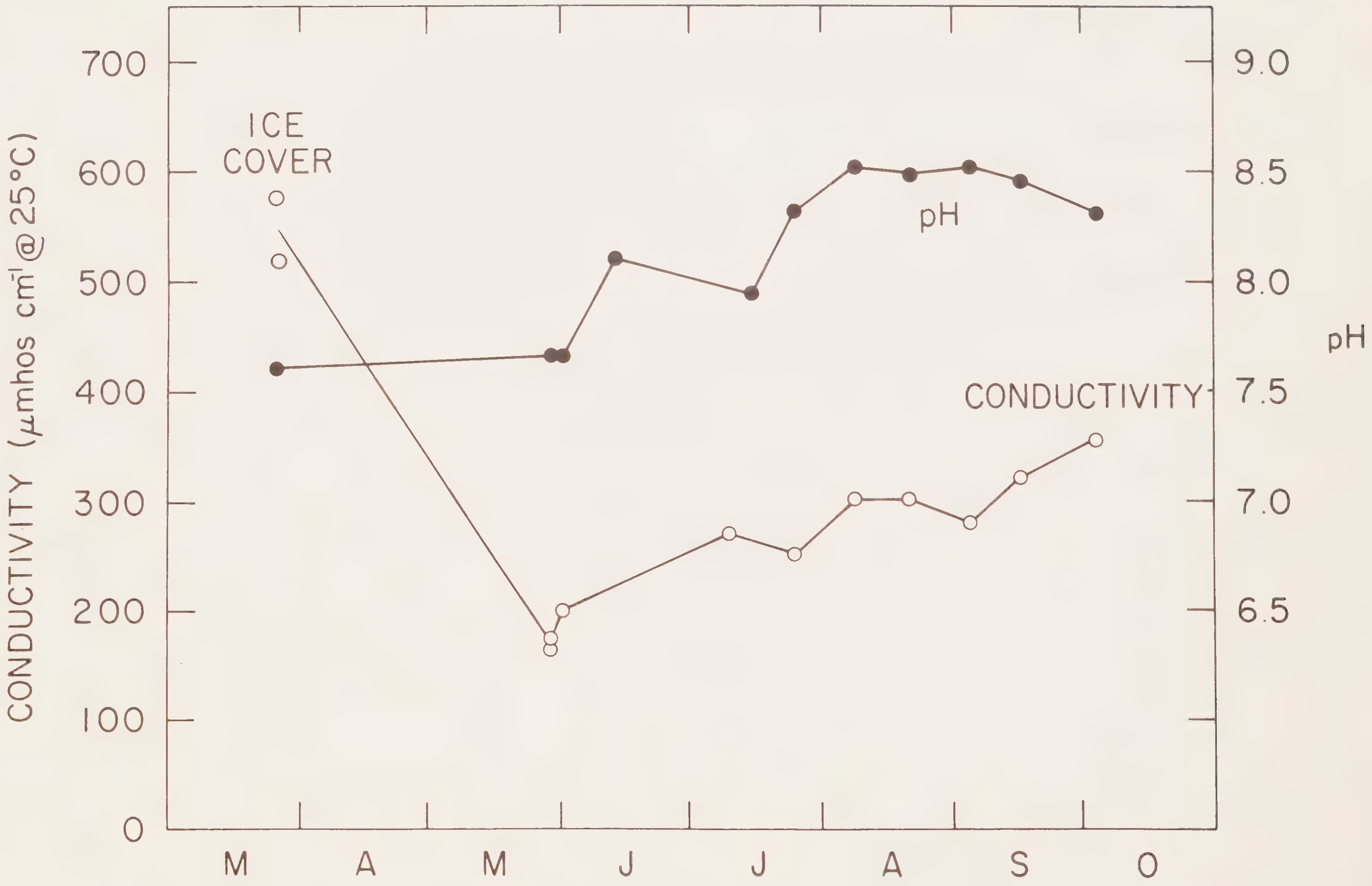


Figure 3b. Seasonal variation of water temperature, dissolved oxygen (O_2), pH and specific conductance at 25°C (cond.). Jean Marie Creek at Mackenzie River (1972).

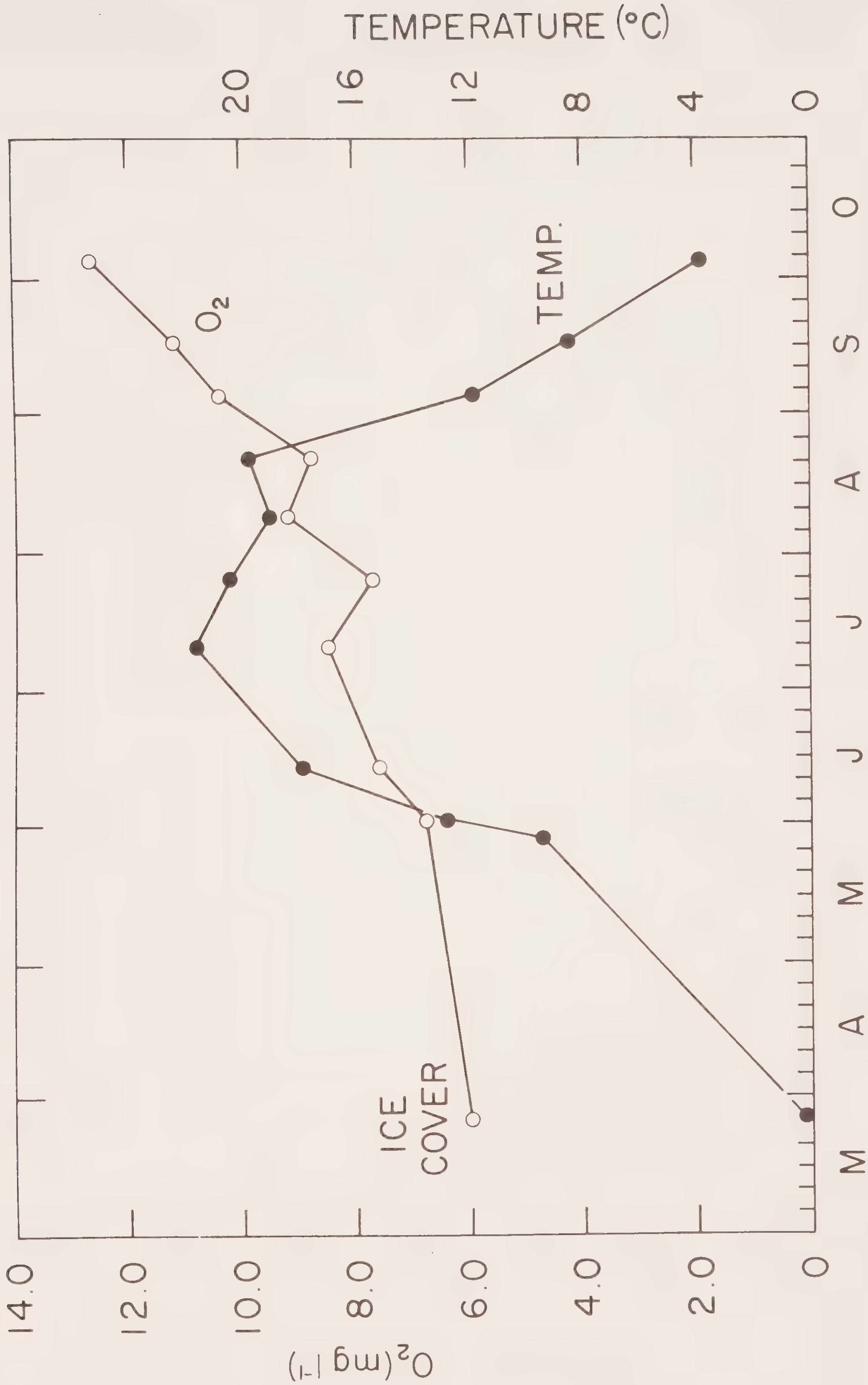


Figure 3b (cont'd).

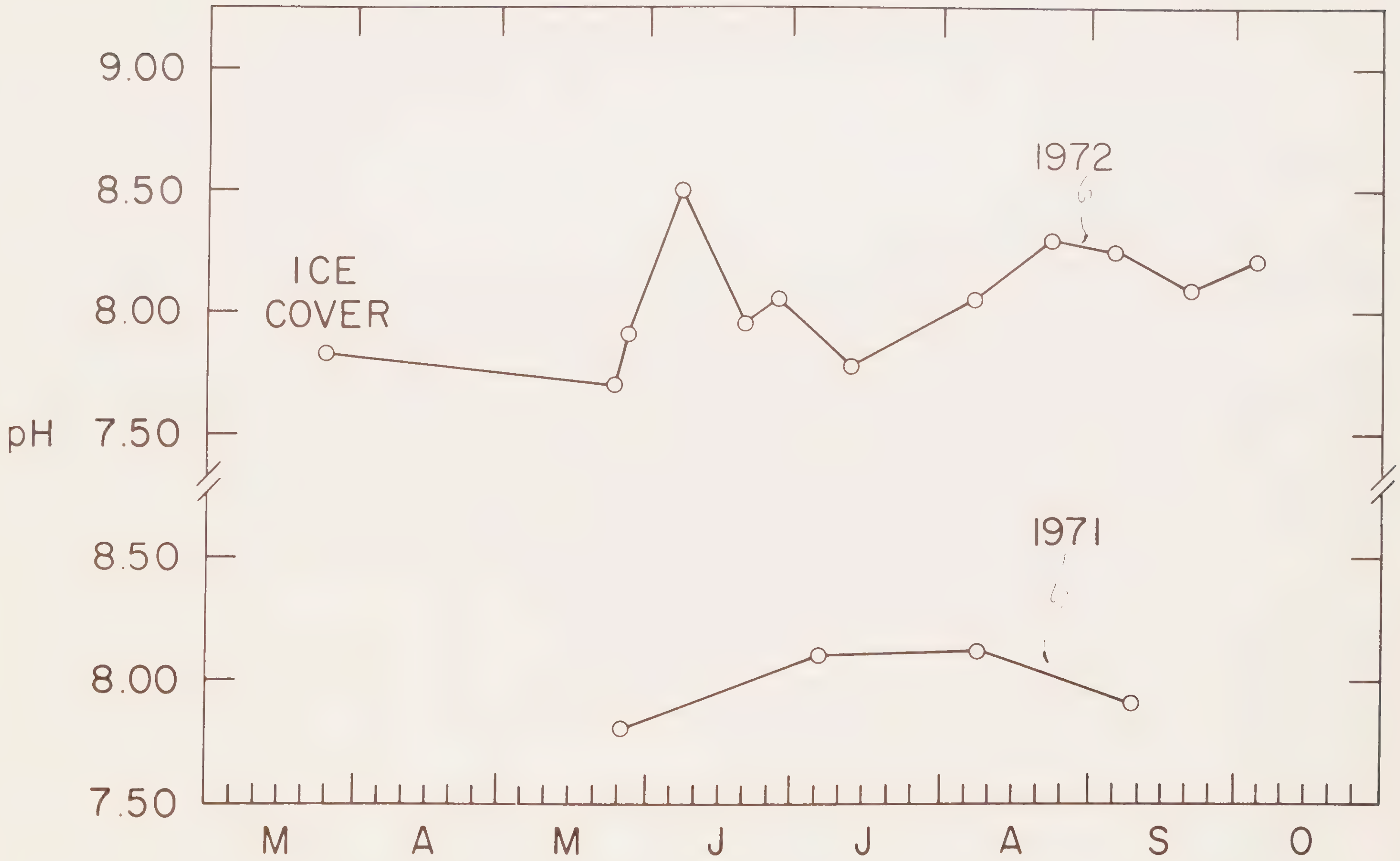


Figure 3d. Seasonal variation of water temperature, dissolved oxygen (O_2), pH and specific conductance at 25°C (cond.). Mackenzie River above Fort Simpson (1971-72).

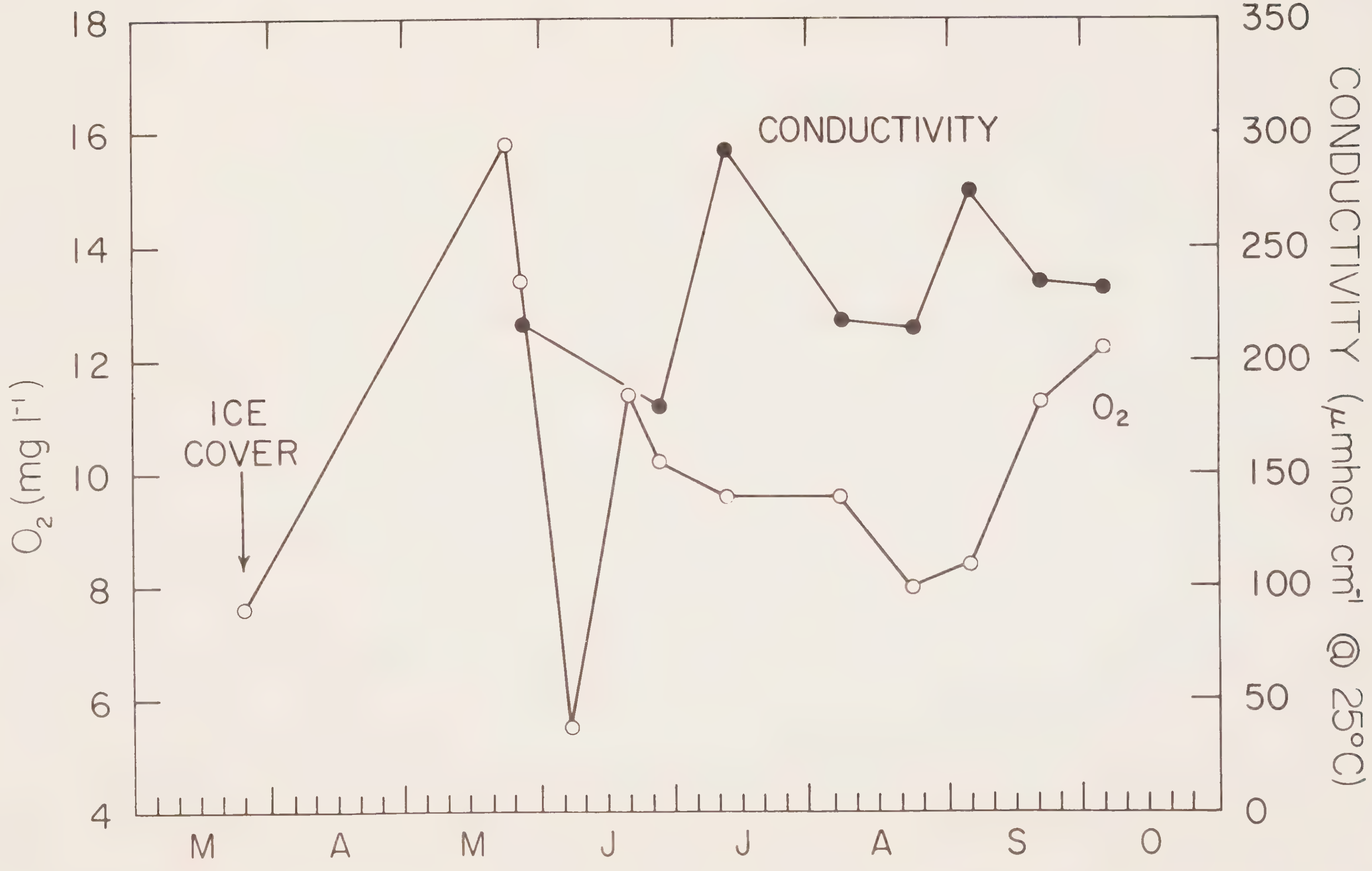


Figure 3e. Seasonal variation of water temperature, dissolved oxygen (O_2), pH and specific conductance at 25°C (cond.). Mackenzie River above Fort Simpson (1972).

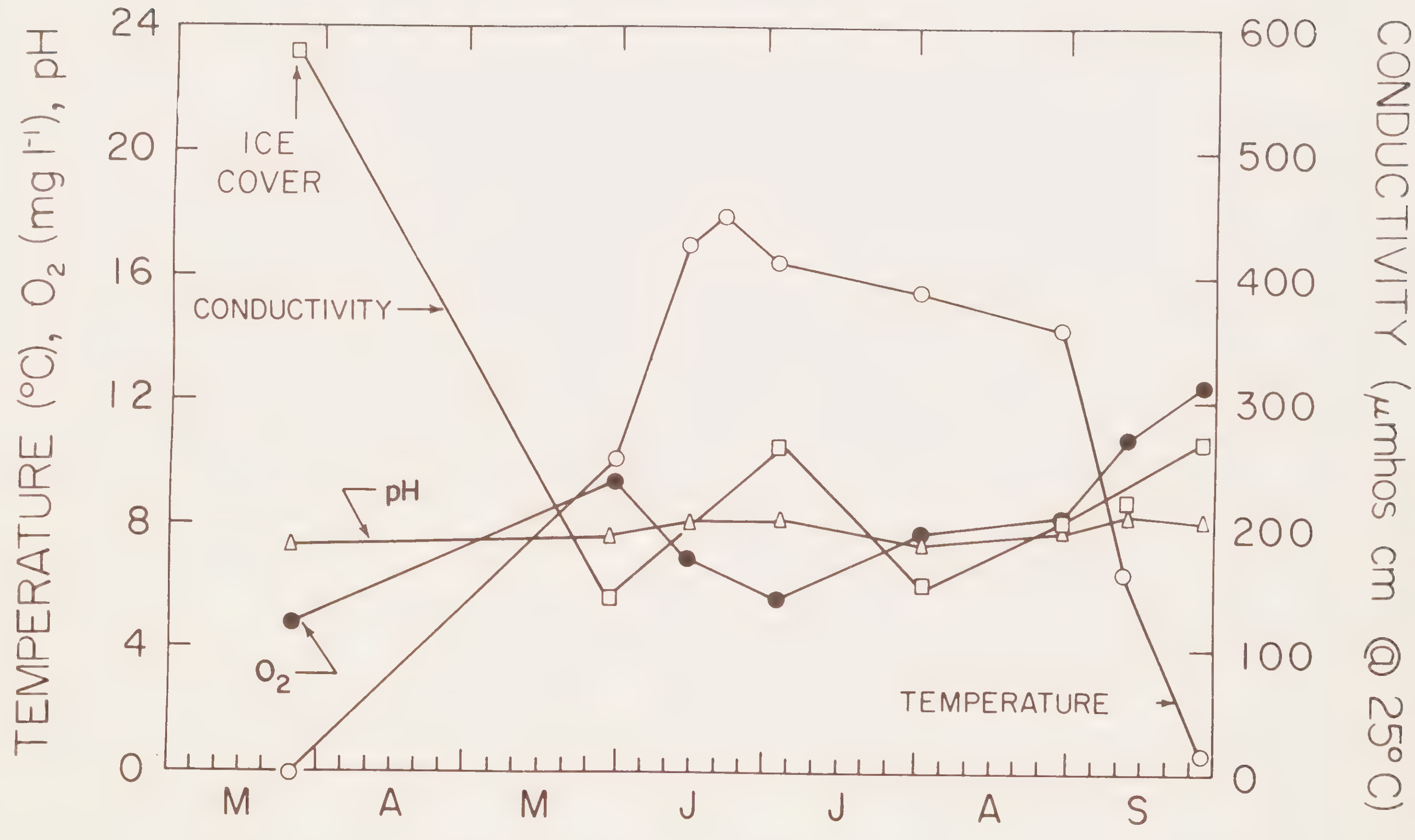


Figure 3f. Seasonal variation of water temperature, dissolved oxygen (0_2), pH and specific conductance at 25°C (cond.). Martin River at Mackenzie River (1972).

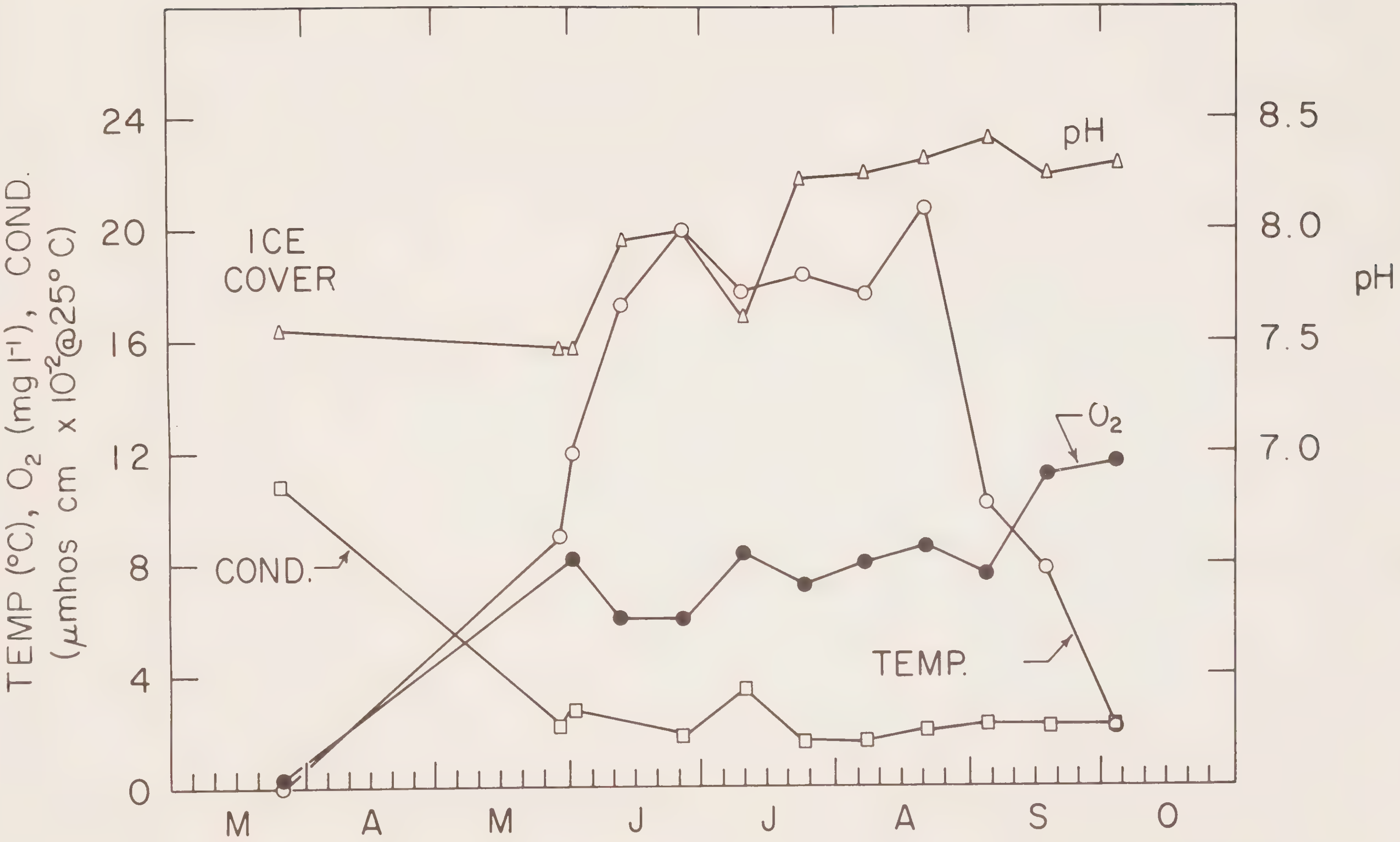


Figure 3g. Seasonal variation of water temperature, dissolved oxygen (O_2), pH and specific conductance at 25°C (cond.). Rabbitskin River at Mackenzie River (1972).

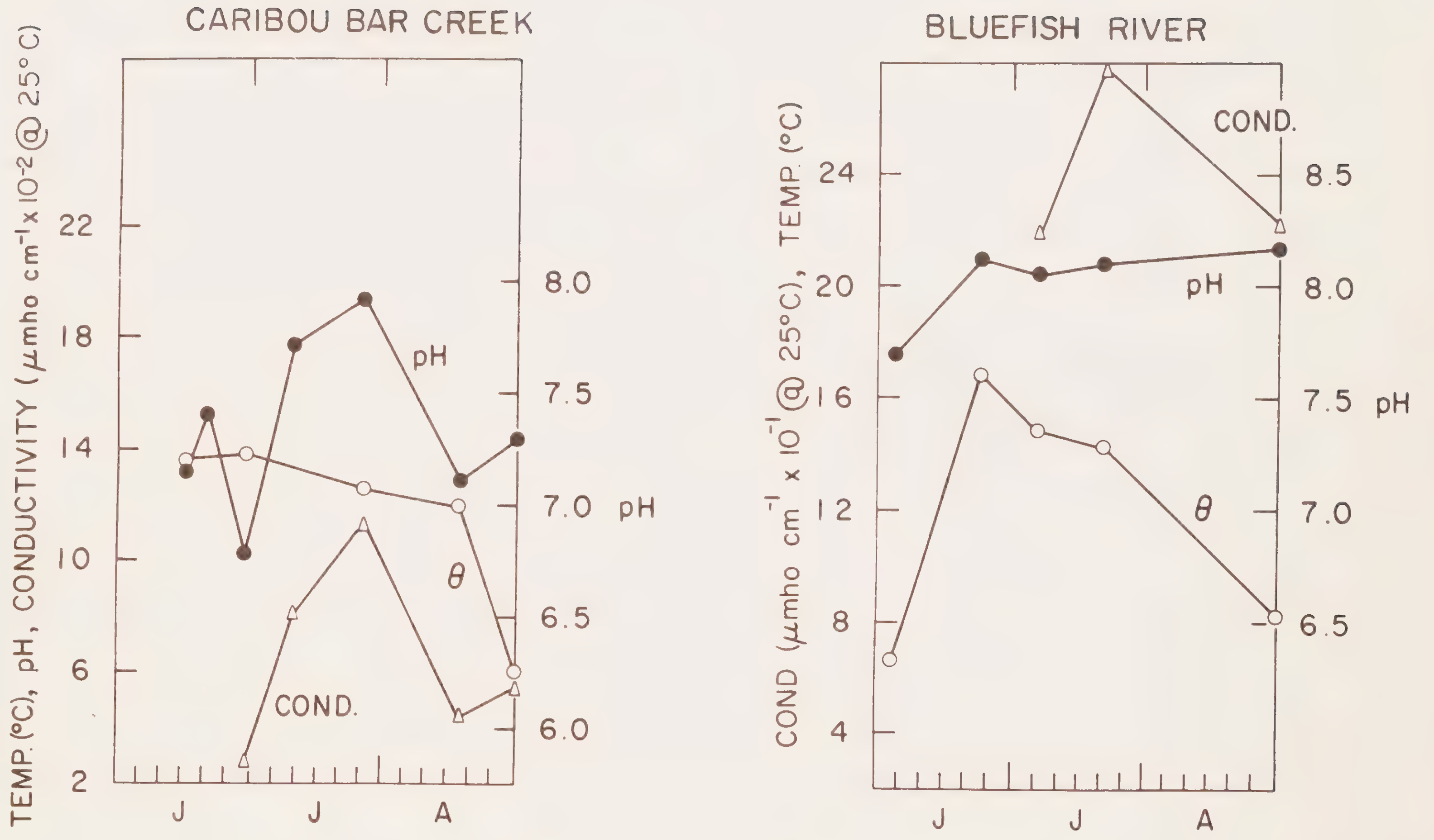


Figure 3h. Seasonal variation of water temperature, dissolved oxygen (O_2), pH and specific conductance at 25°C (cond.). Bluefish River and Caribou Bar Creek (1972).

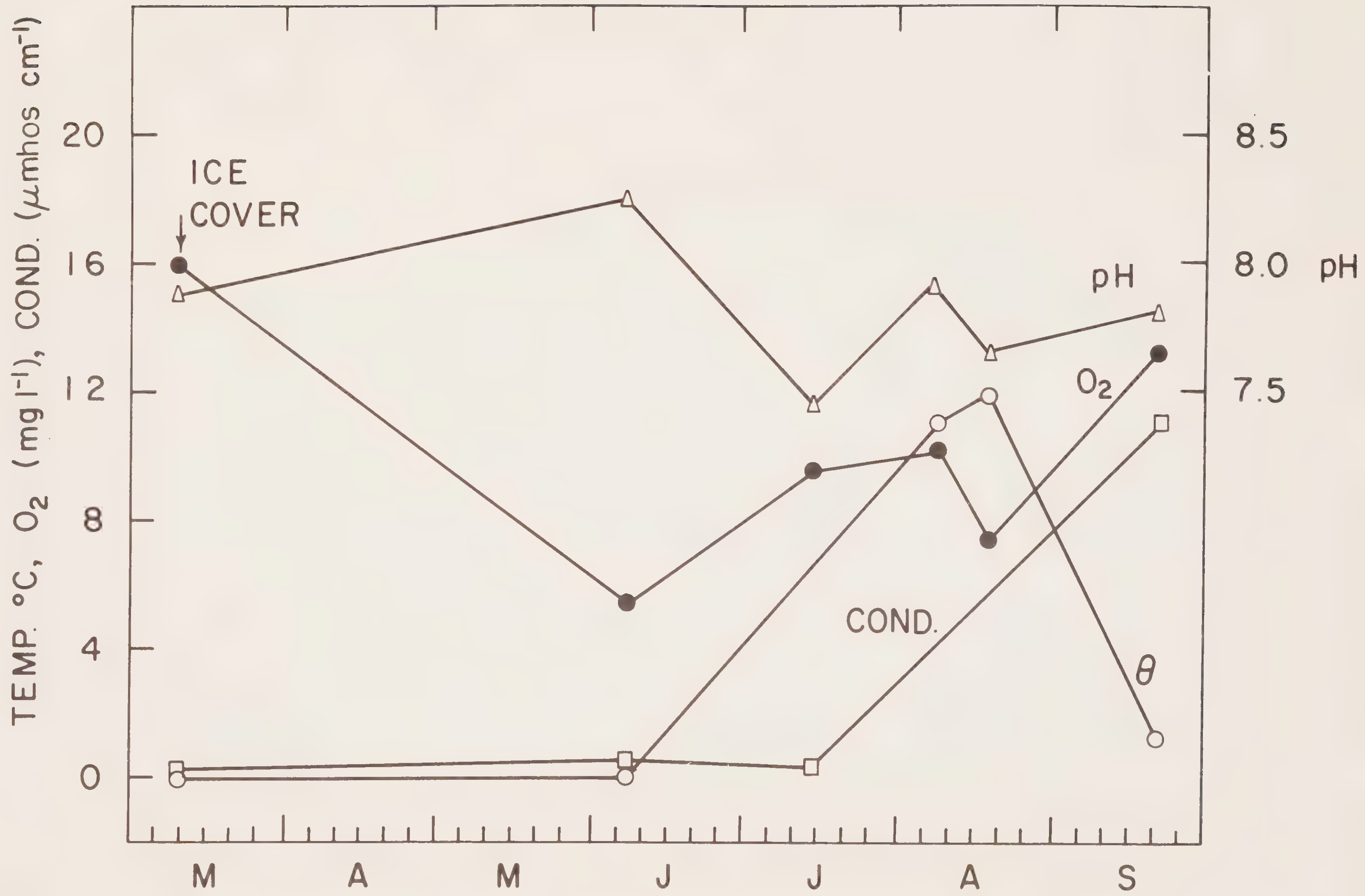


Figure 3i. Seasonal variation of water temperature, dissolved oxygen (O_2), pH and specific conductance at 25°C (cond.). Kugmallit Bay - KU4 (1972).

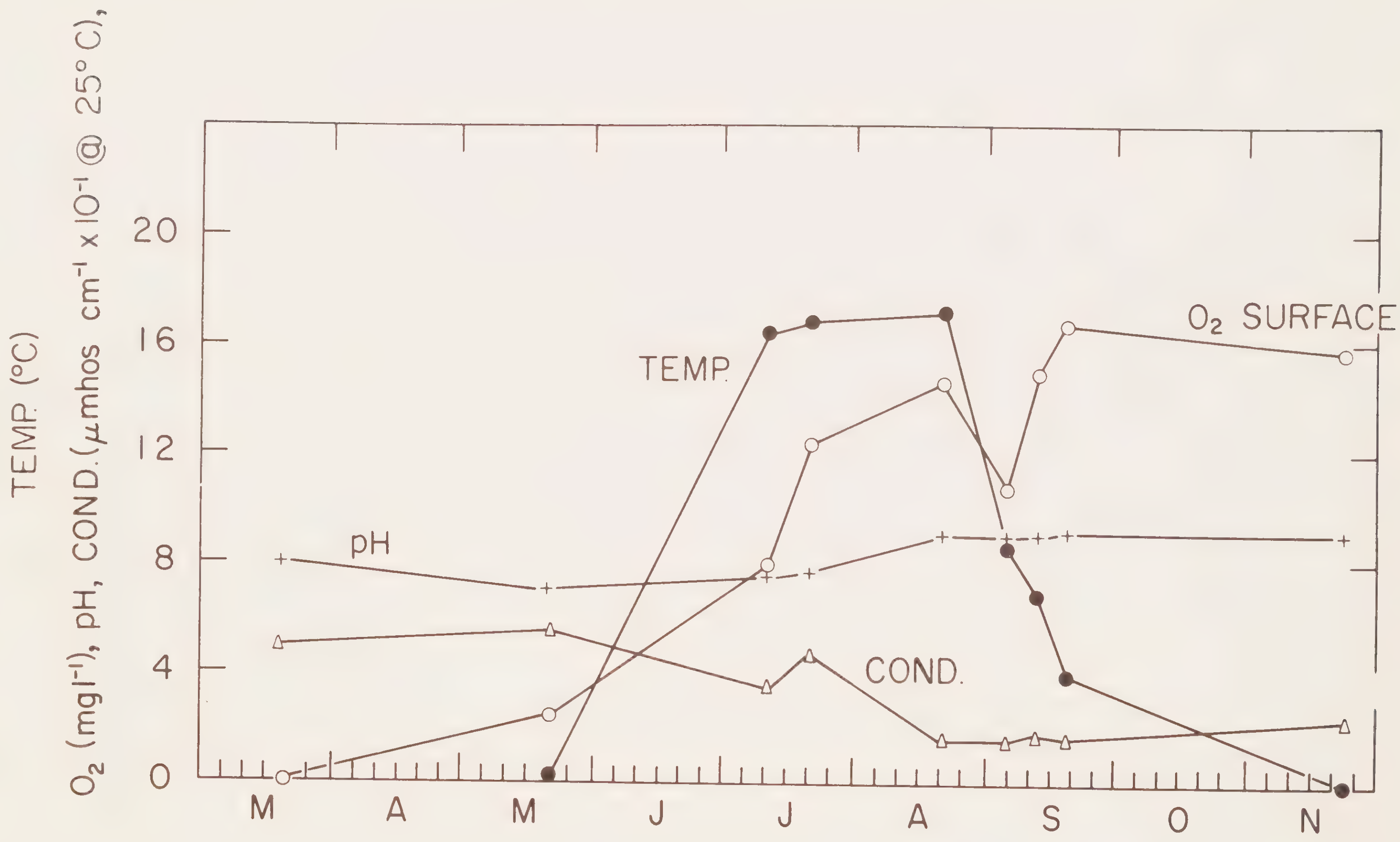


Figure 3j. Seasonal variation of water temperature, dissolved oxygen (O_2), pH and specific conductance at 25%C (cond.). Lake 4 (1972).

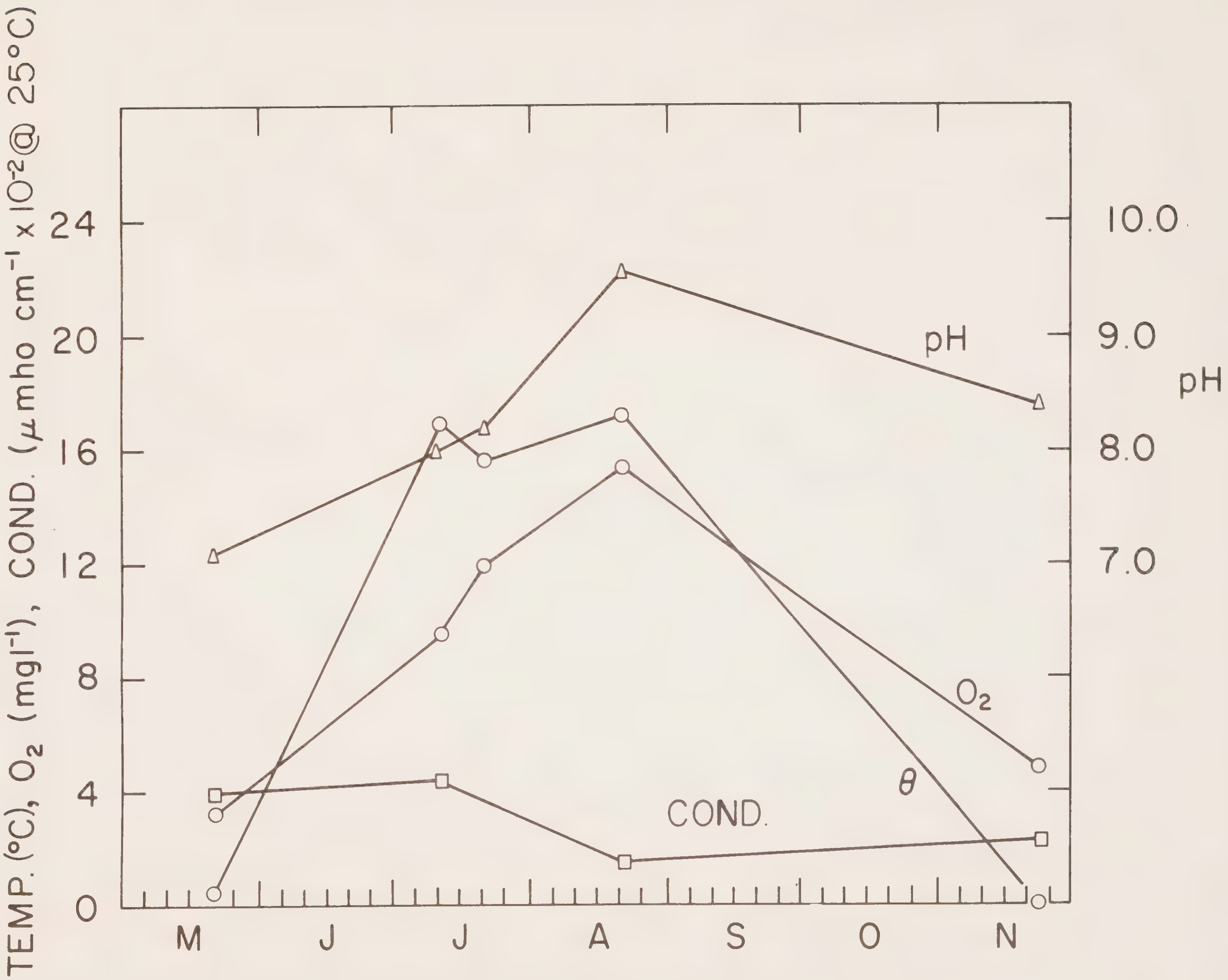


Figure 3k. Seasonal variation of water temperature, dissolved oxygen (O_2), pH and specific conductance at 25°C (cond.). Lake C4 (1972).

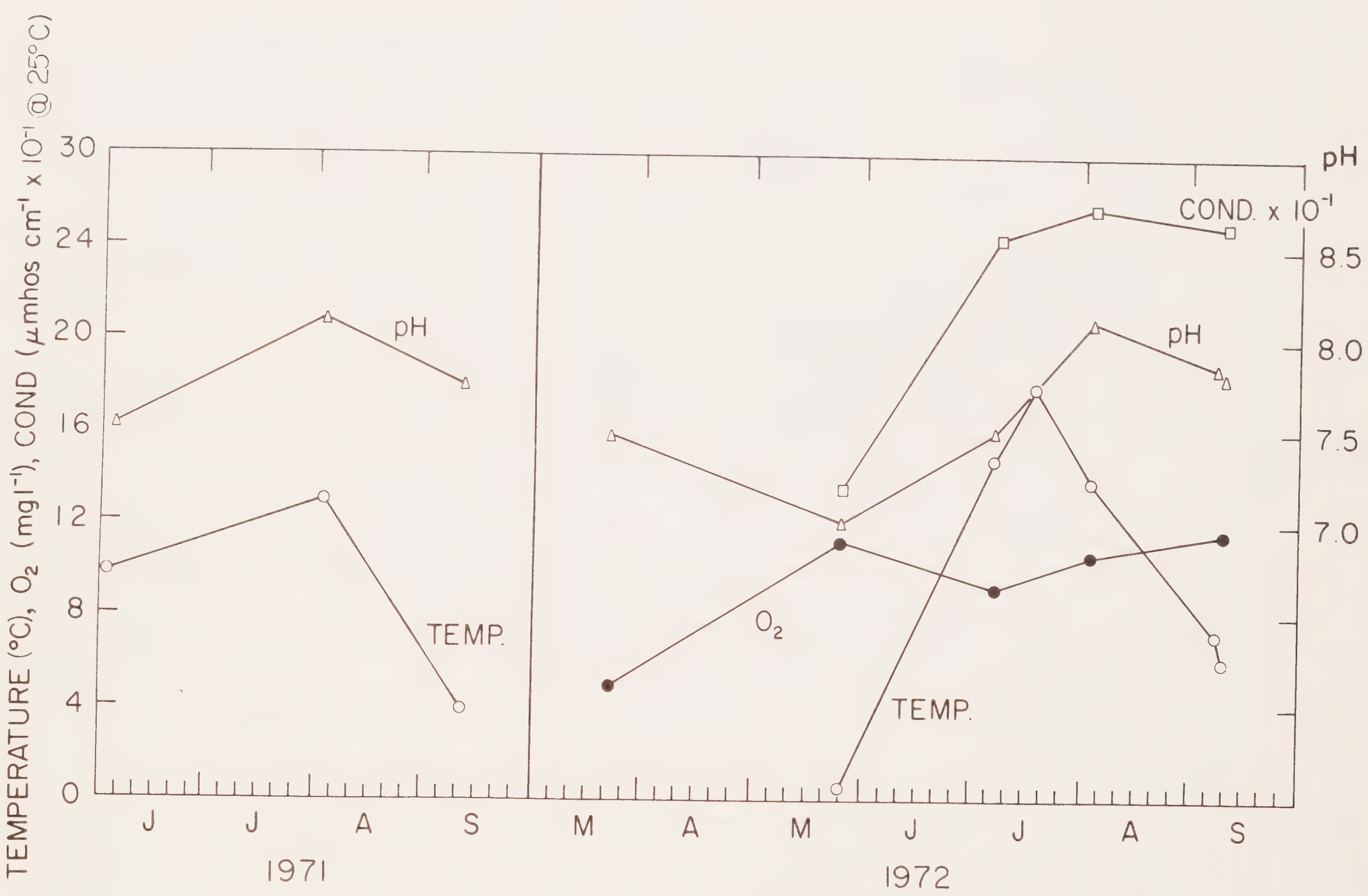


Figure 51. Seasonal variation of water temperature, dissolved oxygen (O_2), pH and specific conductance at 25°C (cond.). Peel River at Fort McPherson (1971-72).

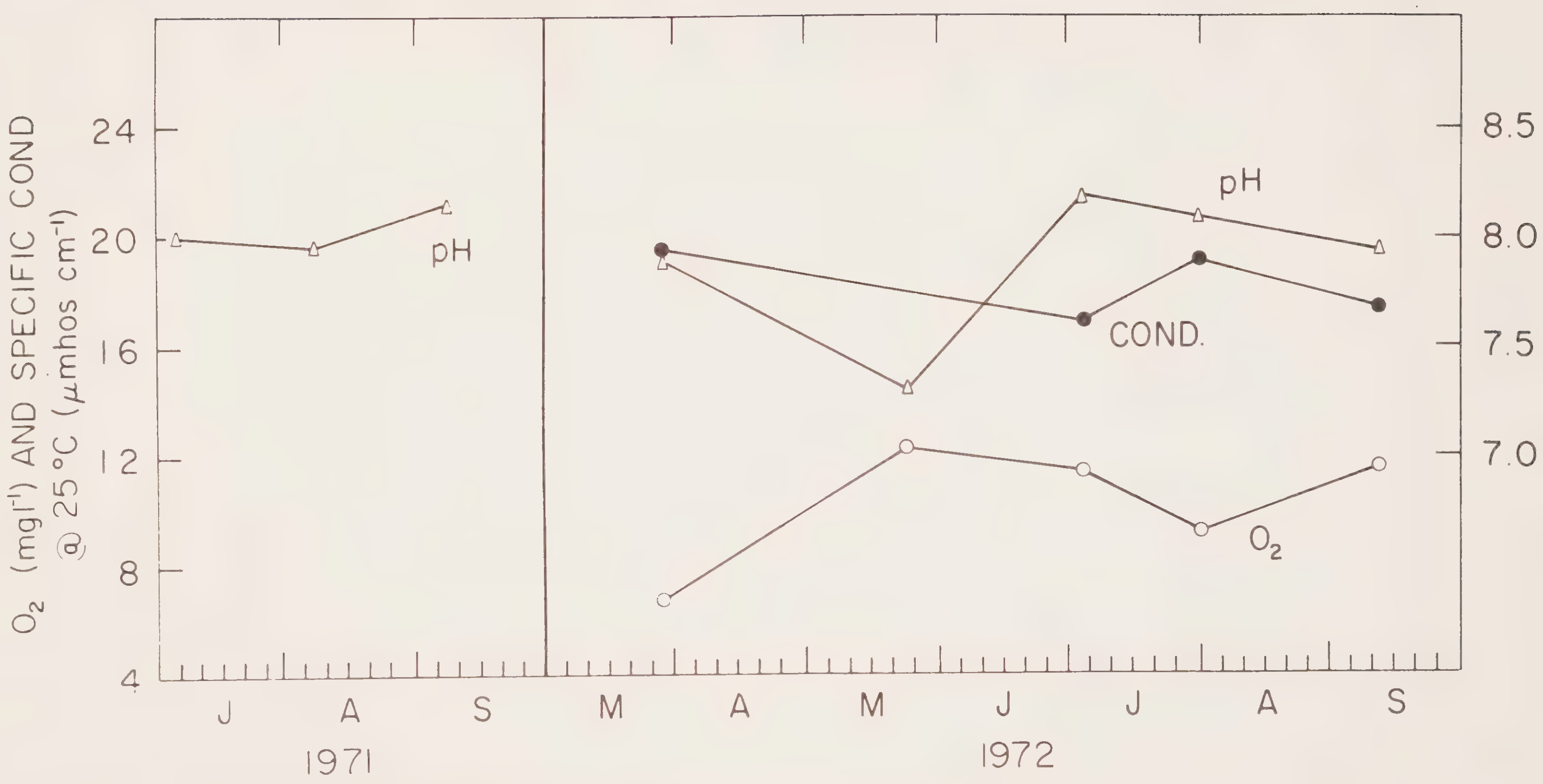


Figure 3m. Seasonal variation of water temperature, dissolved oxygen (O_2), pH and specific conductance at 25°C (cond.). Mackenzie River at Fort Providence (1972).

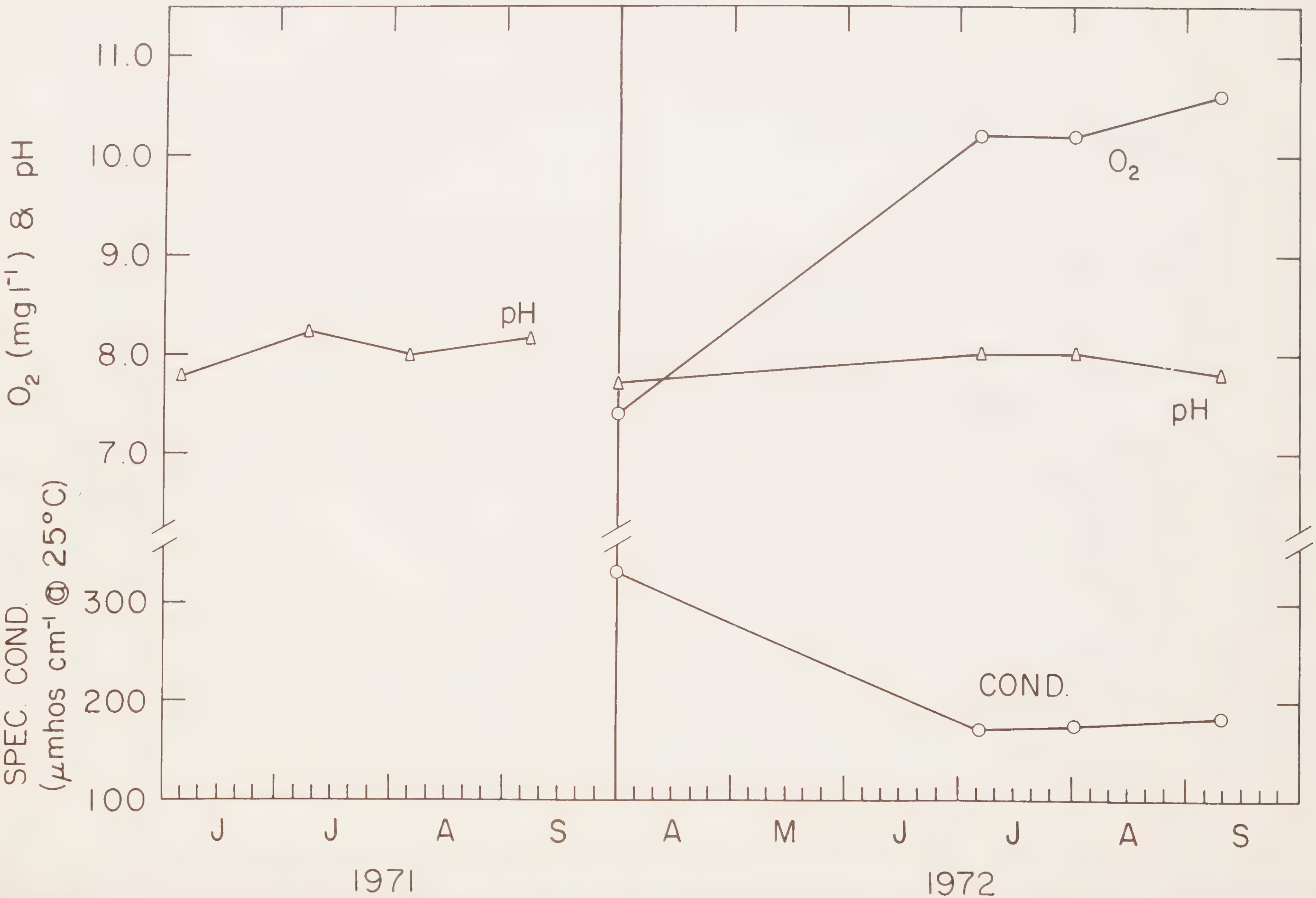


Figure 3n. Seasonal variation of water temperature, dissolved oxygen (O_2), pH and specific conductance at 25°C (cond.). Mackenzie River at Norman Wells (1972).

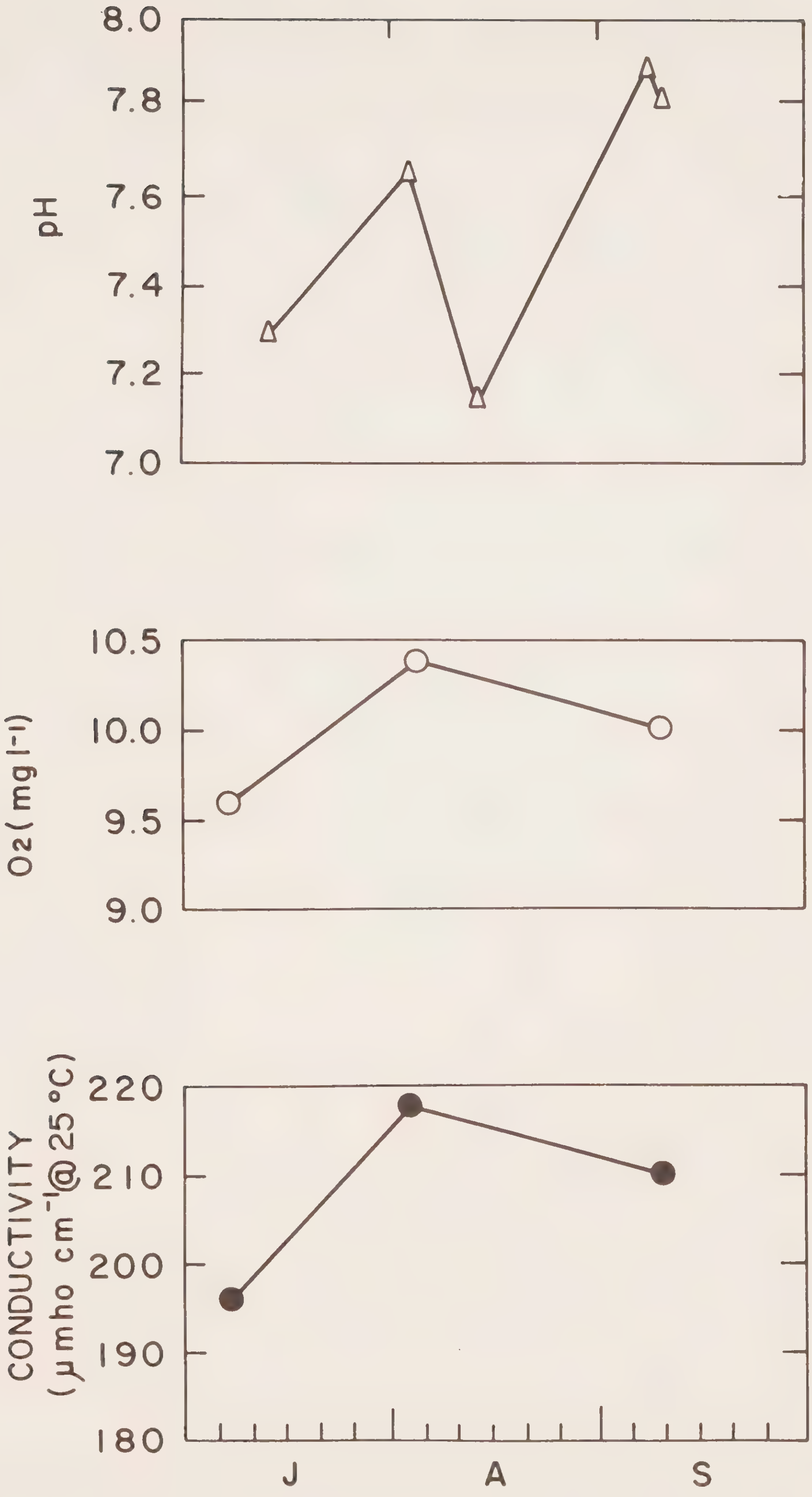


Figure 3o. Seasonal variation of water temperature, dissolved oxygen (O_2), pH and specific conductance at 25°C (cond.). Mackenzie River at Arctic Red River (1972).

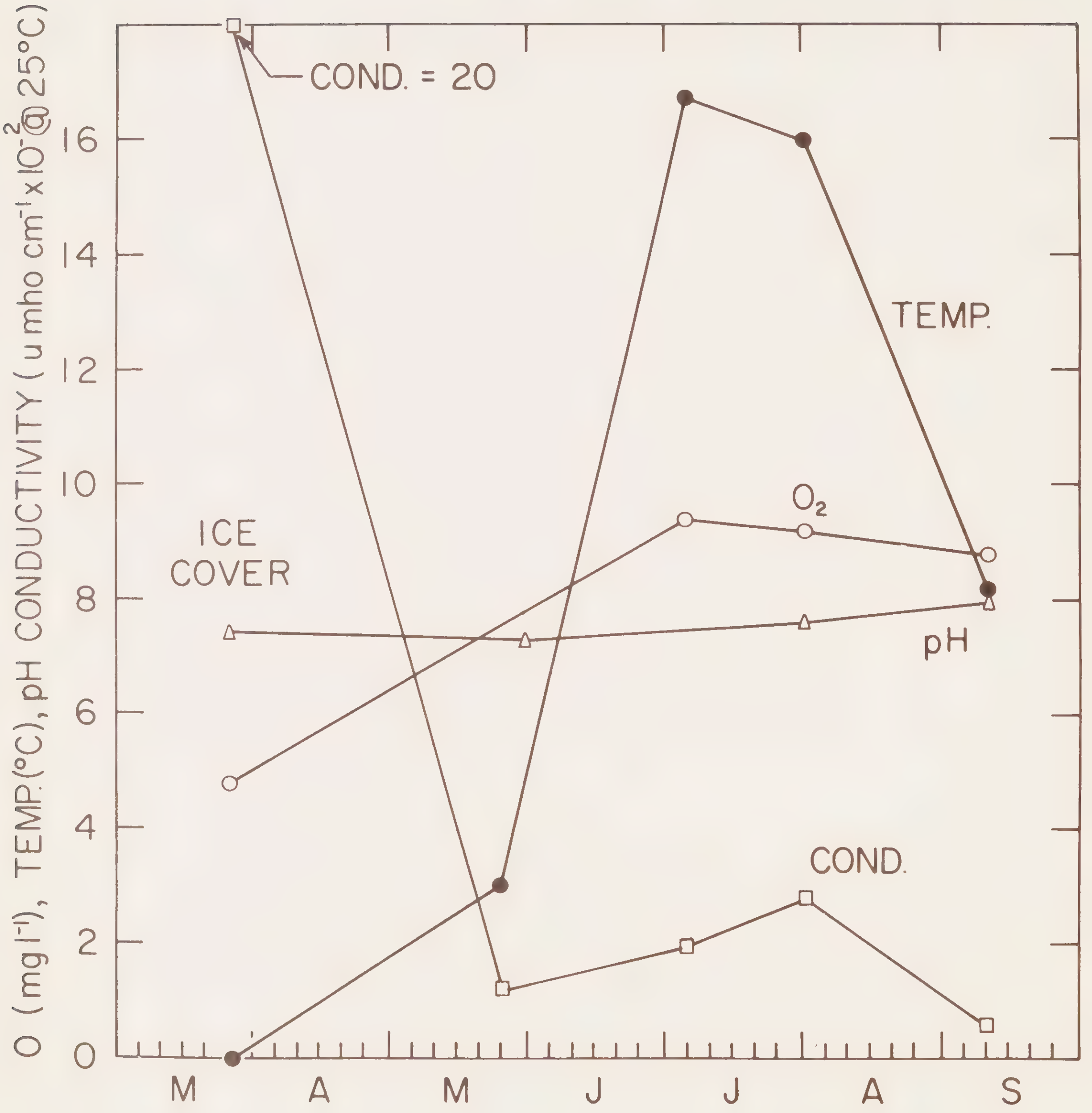


Figure 3p. Seasonal variation of water temperature, dissolved oxygen (O_2), pH and specific conductance at 25°C (cond.). Willowlake River (1972).

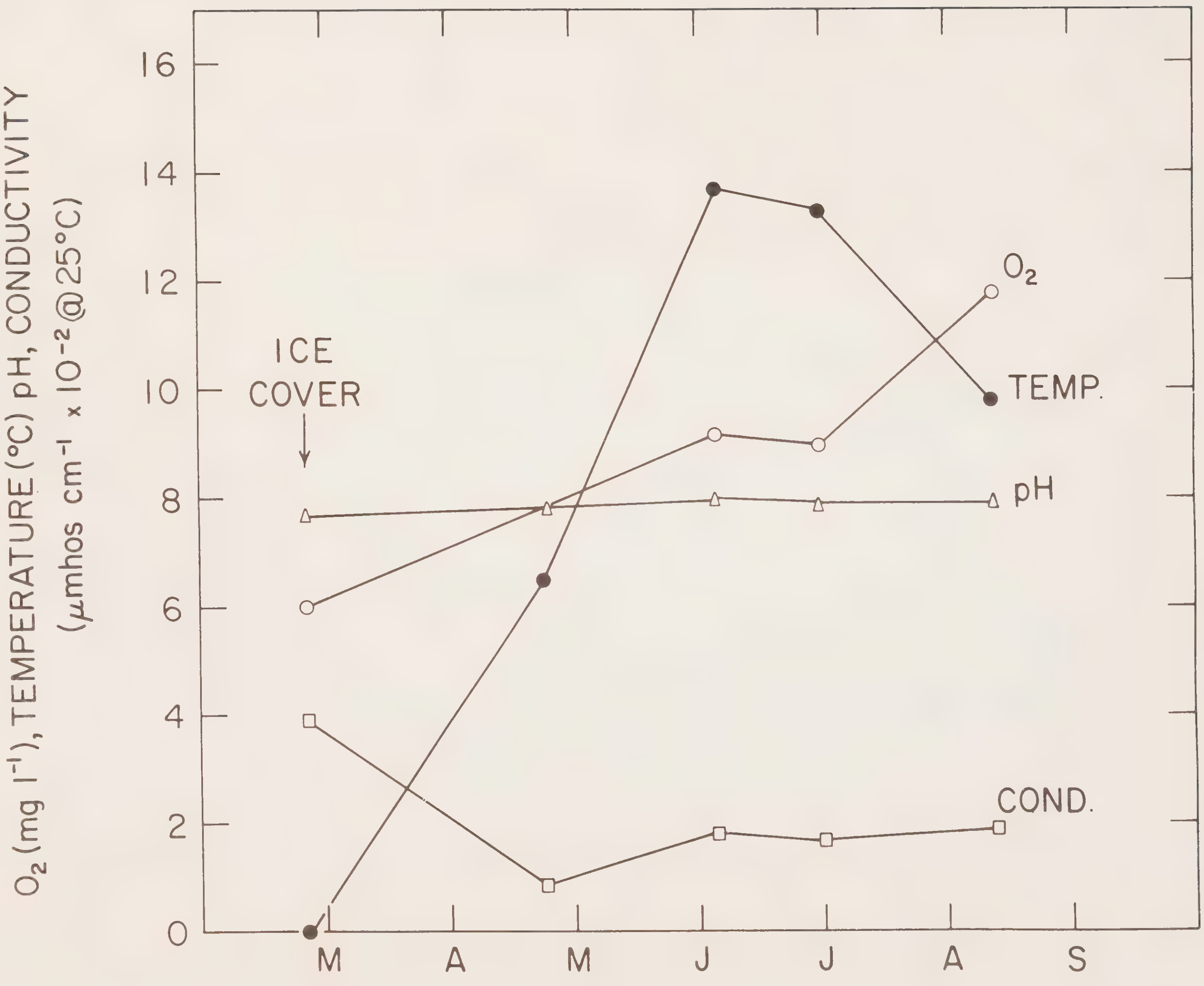


Figure 3q. Seasonal variation of water temperature, dissolved oxygen (O_2), pH and specific conductance at 25°C (cond.). Liard River at Fort Liard (1972).

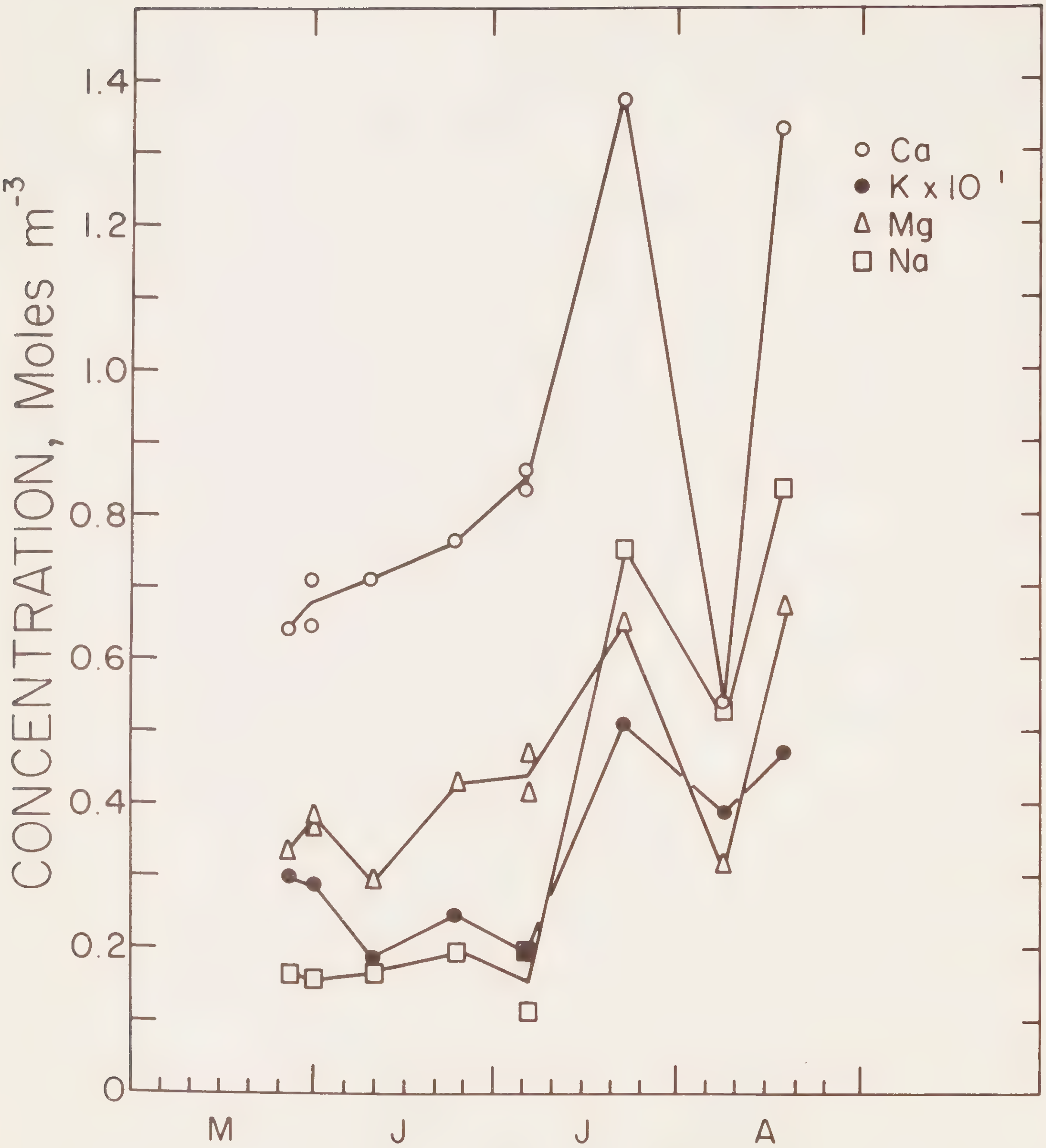


Figure 4a. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). Harris River at Mackenzie River (1972).

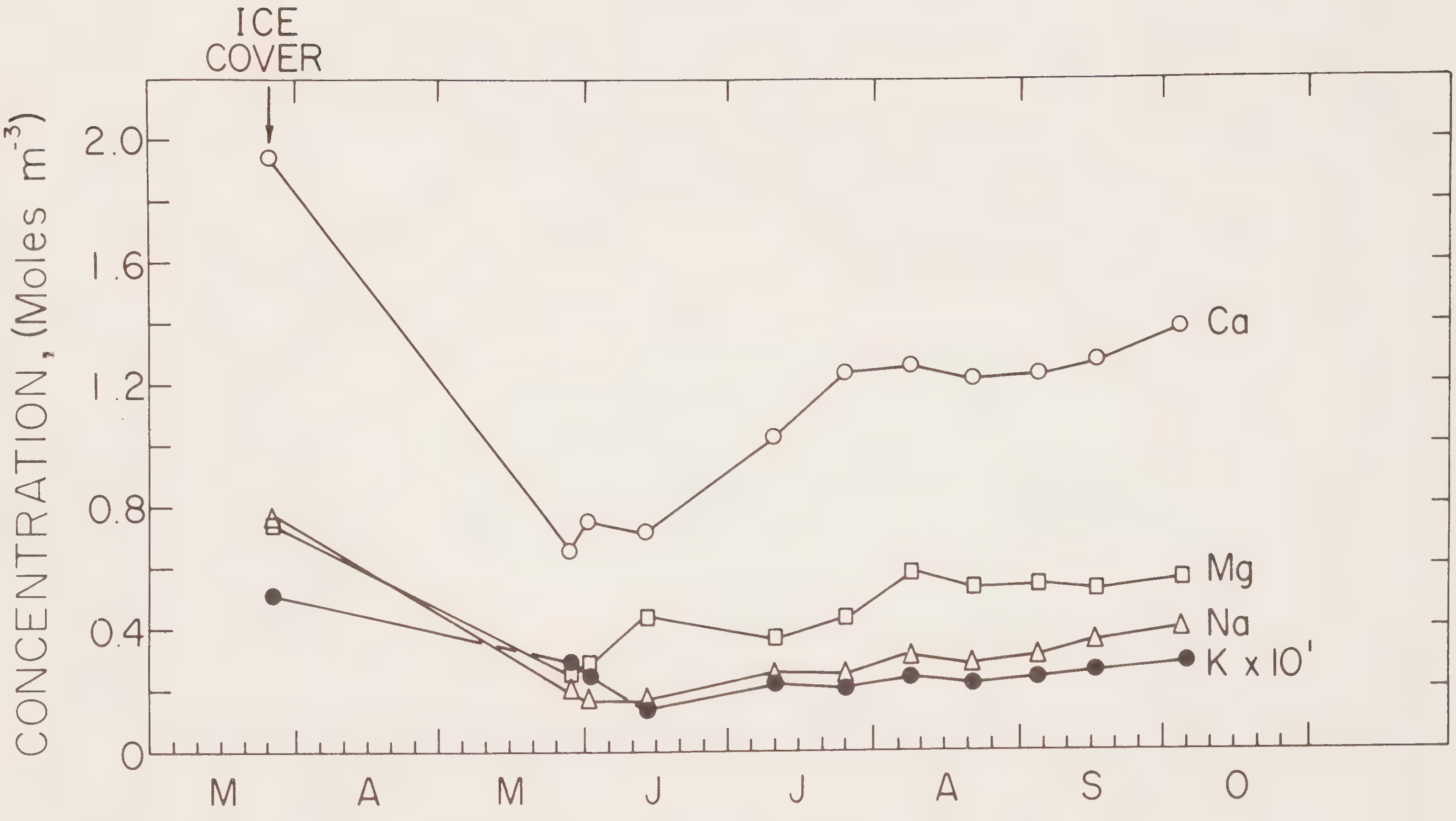


Figure 4b. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). Jean Marie Creek at Mackenzie River (1972).

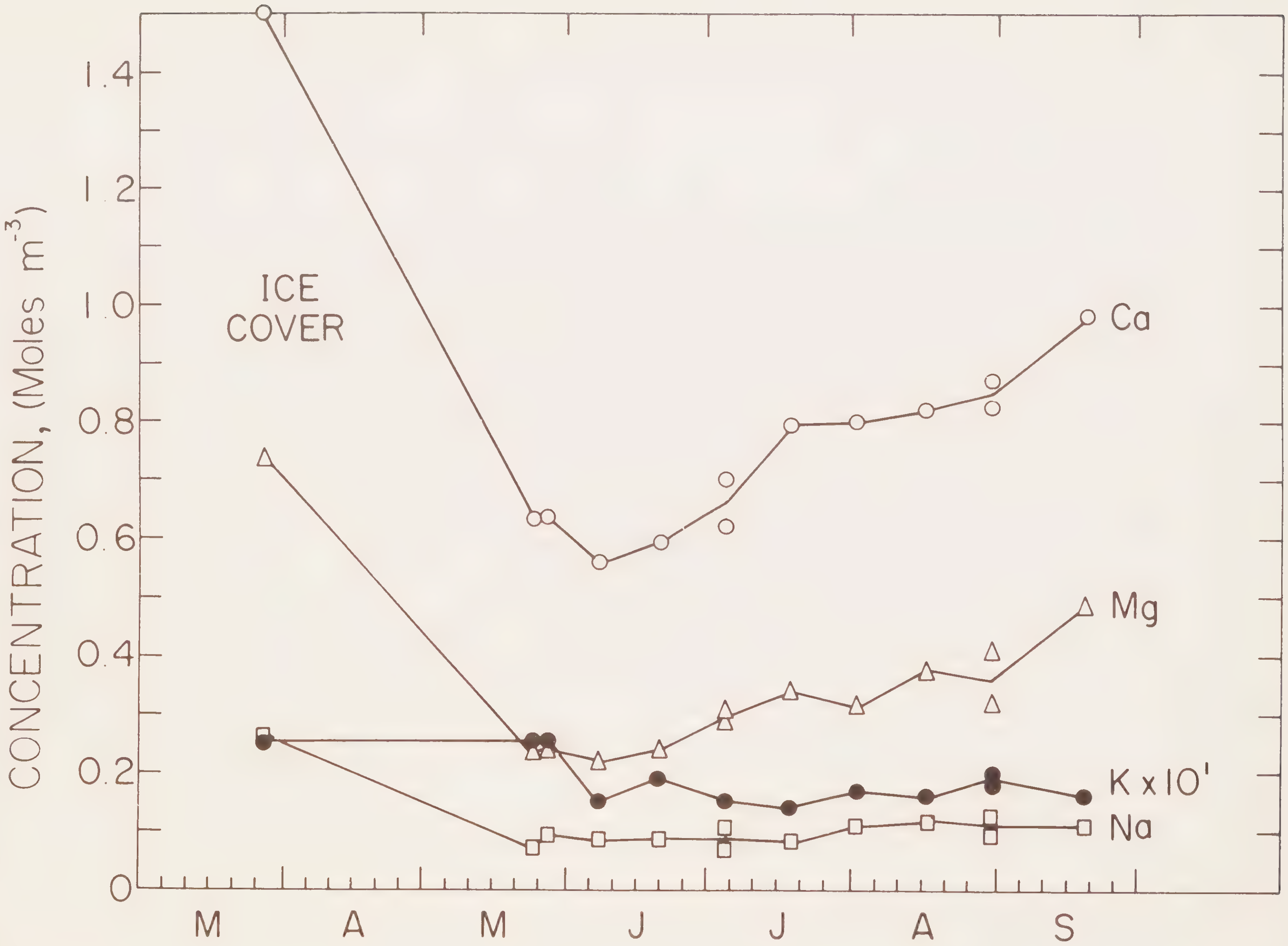


Figure 4c. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). Liard River at Fort Simpson (1972).

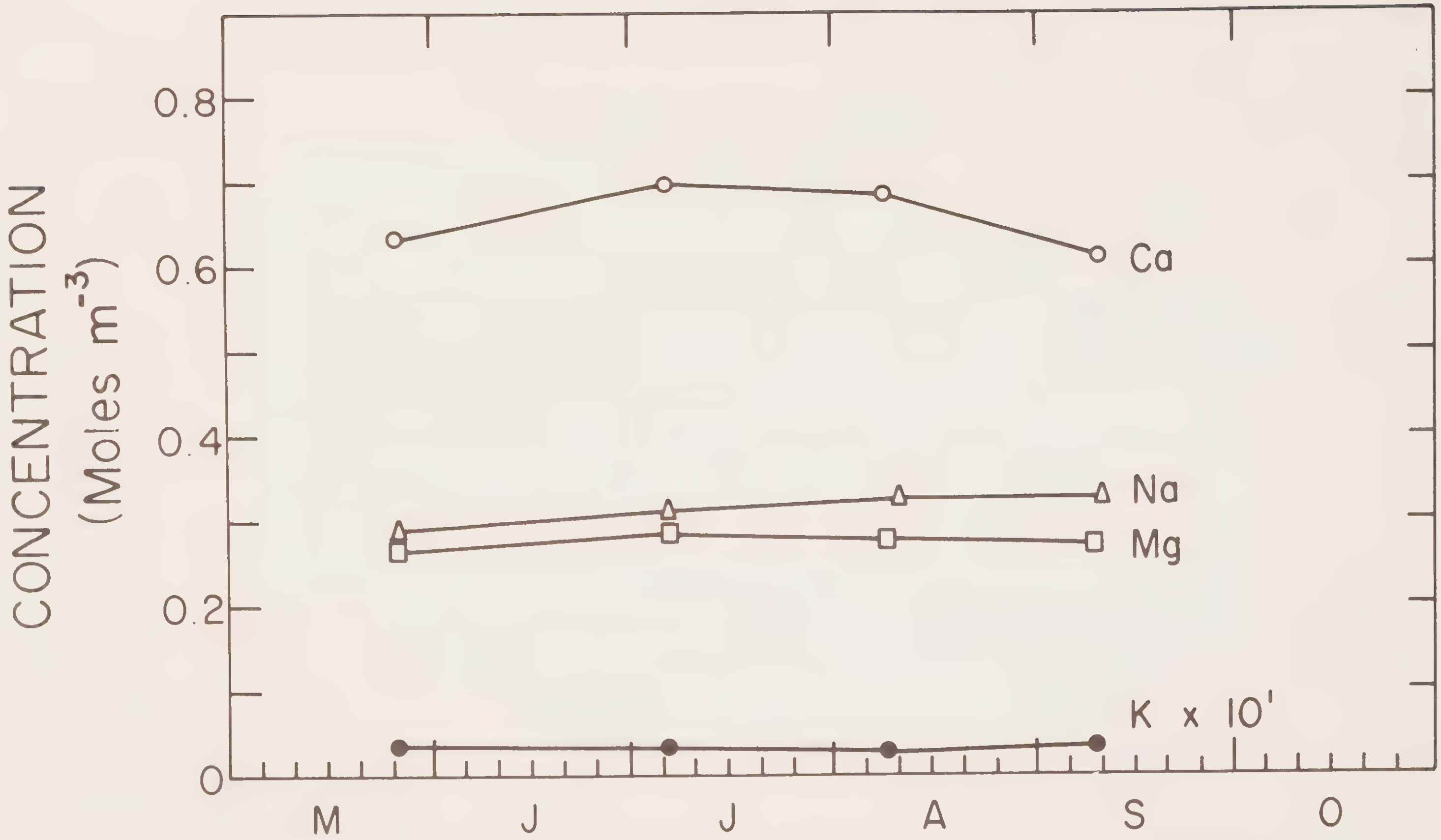


Figure 4d. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). Mackenzie River above Fort Simpson (1971).

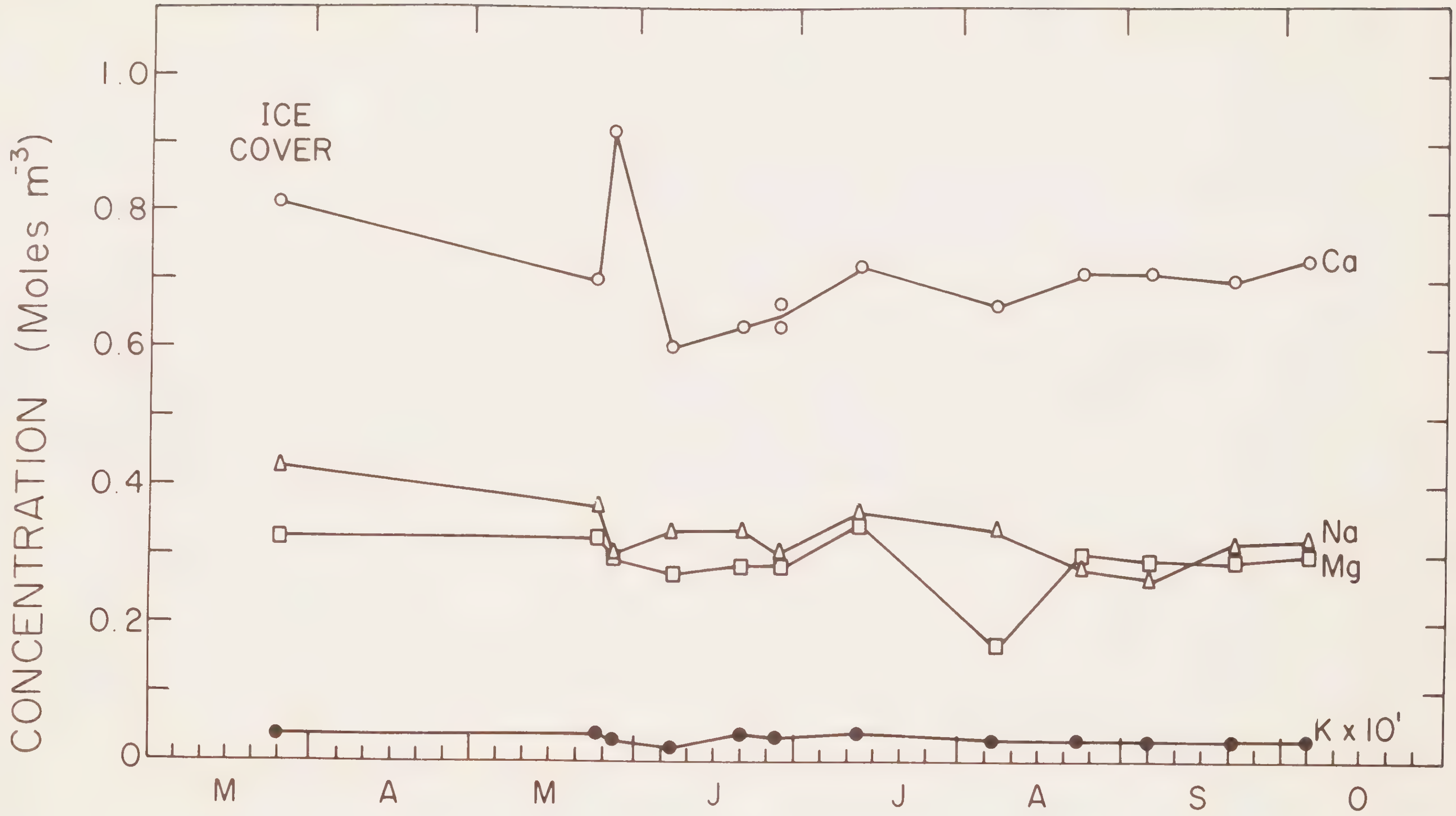


Figure 4e. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K). Mackenzie River above Fort Simpson (1972).

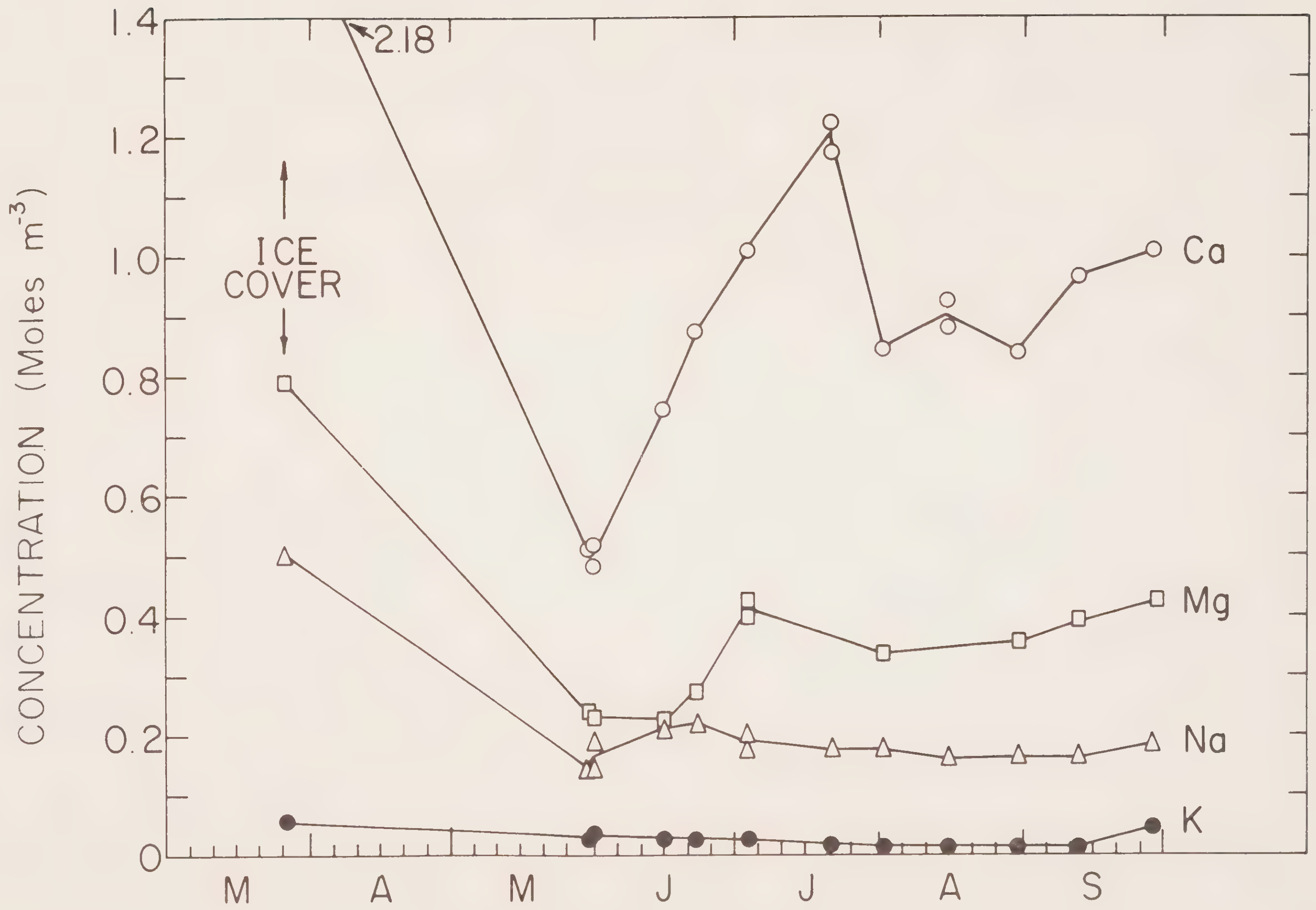


Figure 4f. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). Martin River at Mackenzie River (1972).

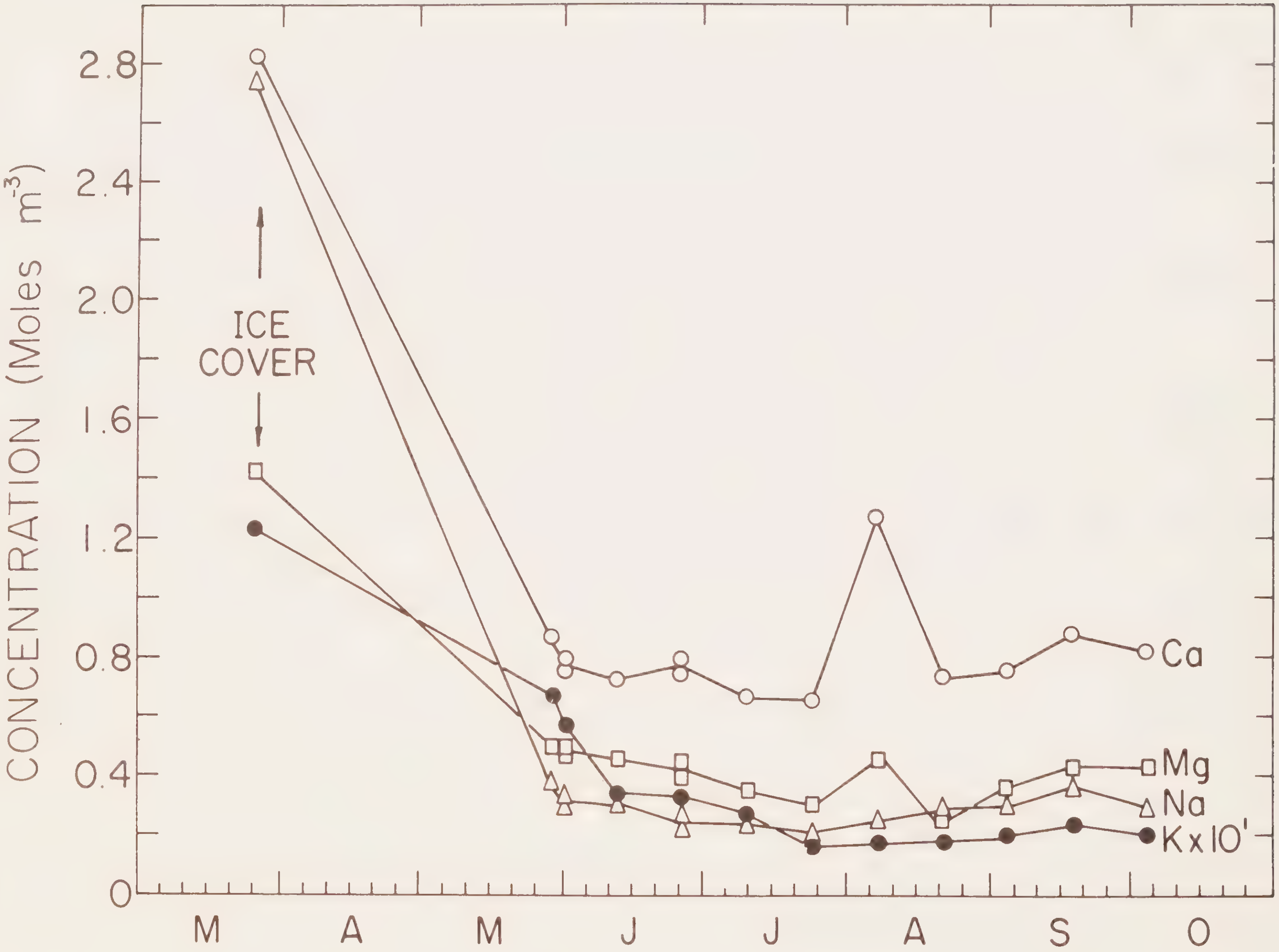


Figure 4g. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). Rabbitskin River at Mackenzie River (1972).

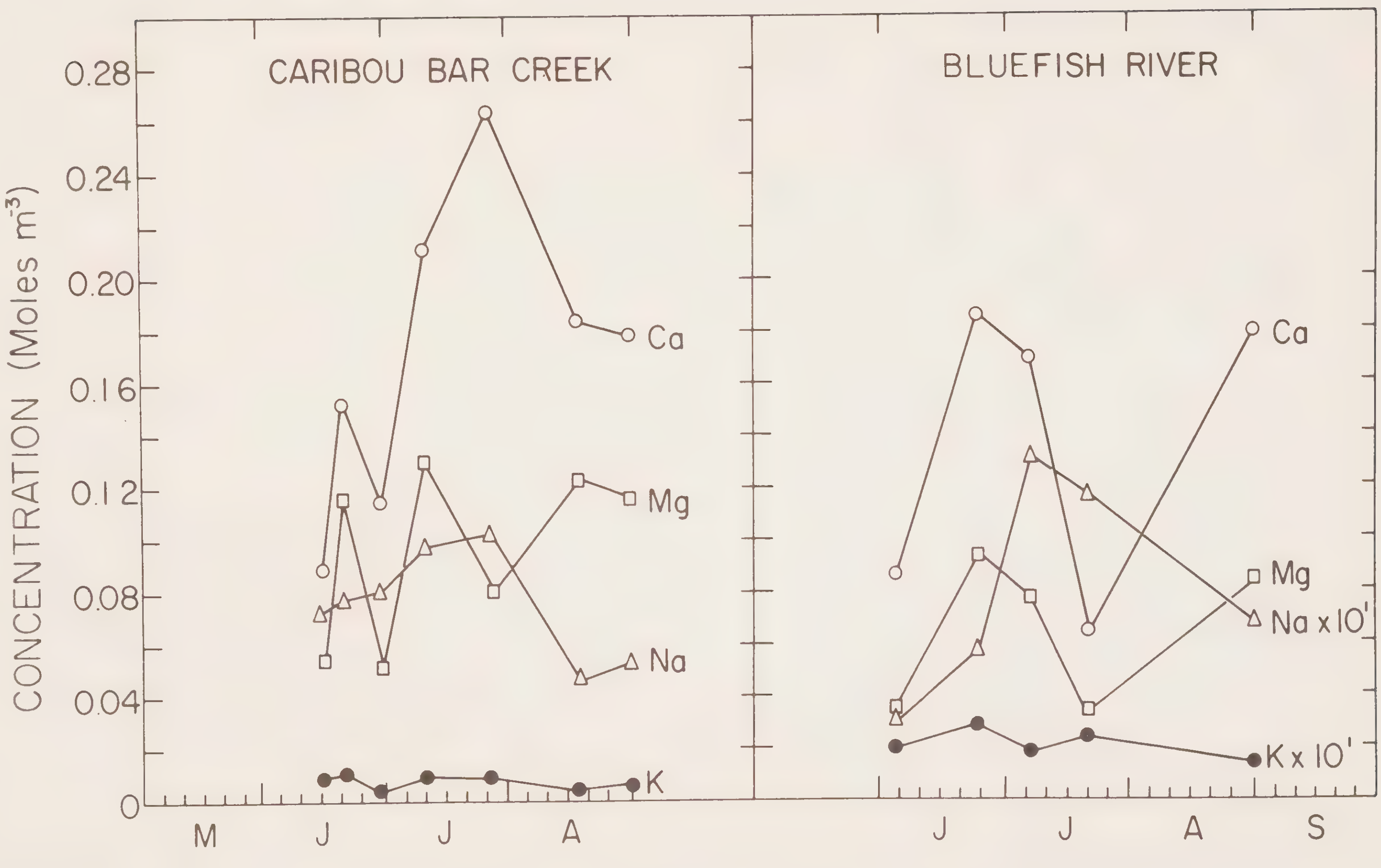


Figure 4h. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). Bluefish River at Mackenzie River (1972).

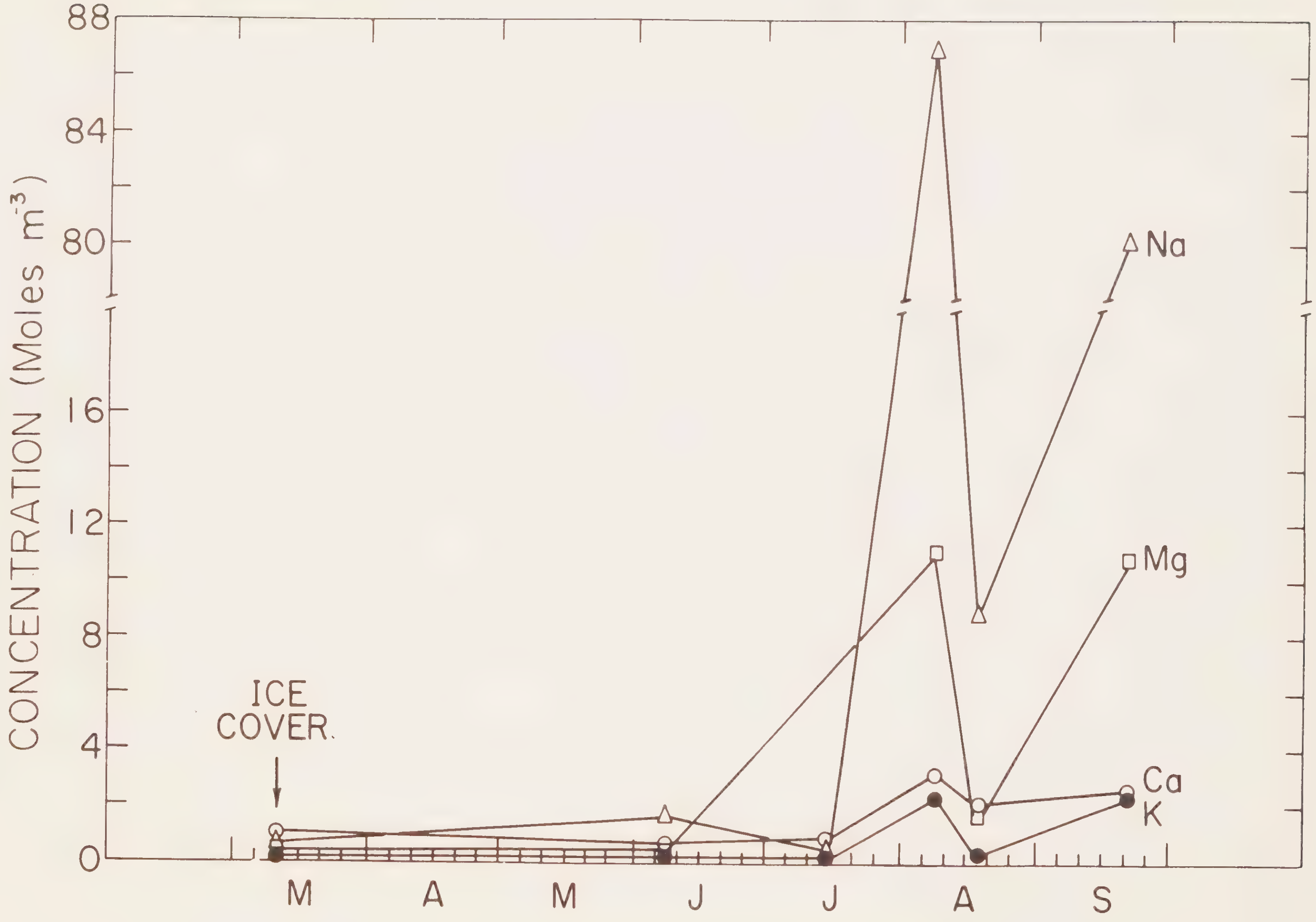


Figure 4i. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). Kugmallit Bay - KU4 (1972).

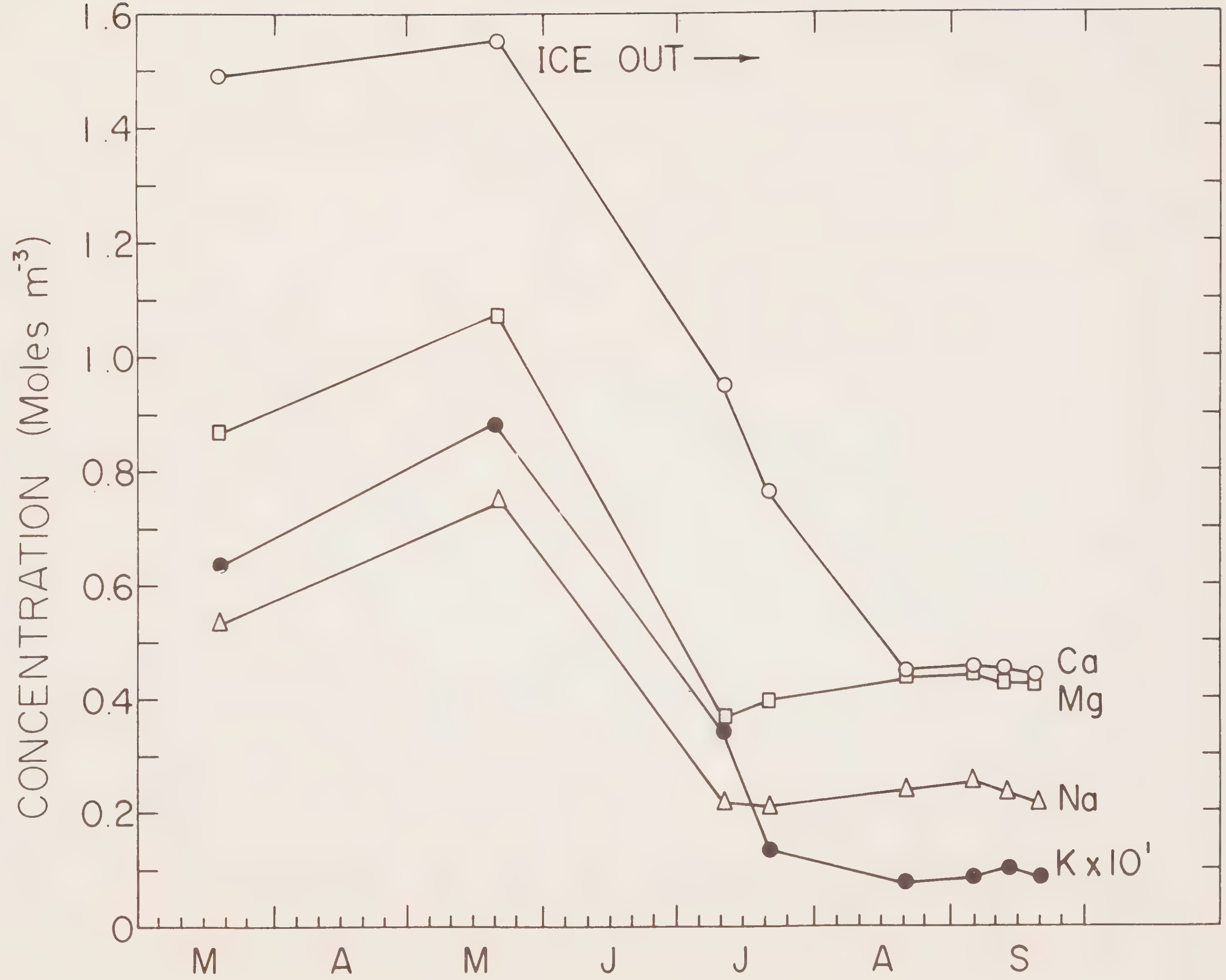


Figure 4j. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). Lake 4 (1972).

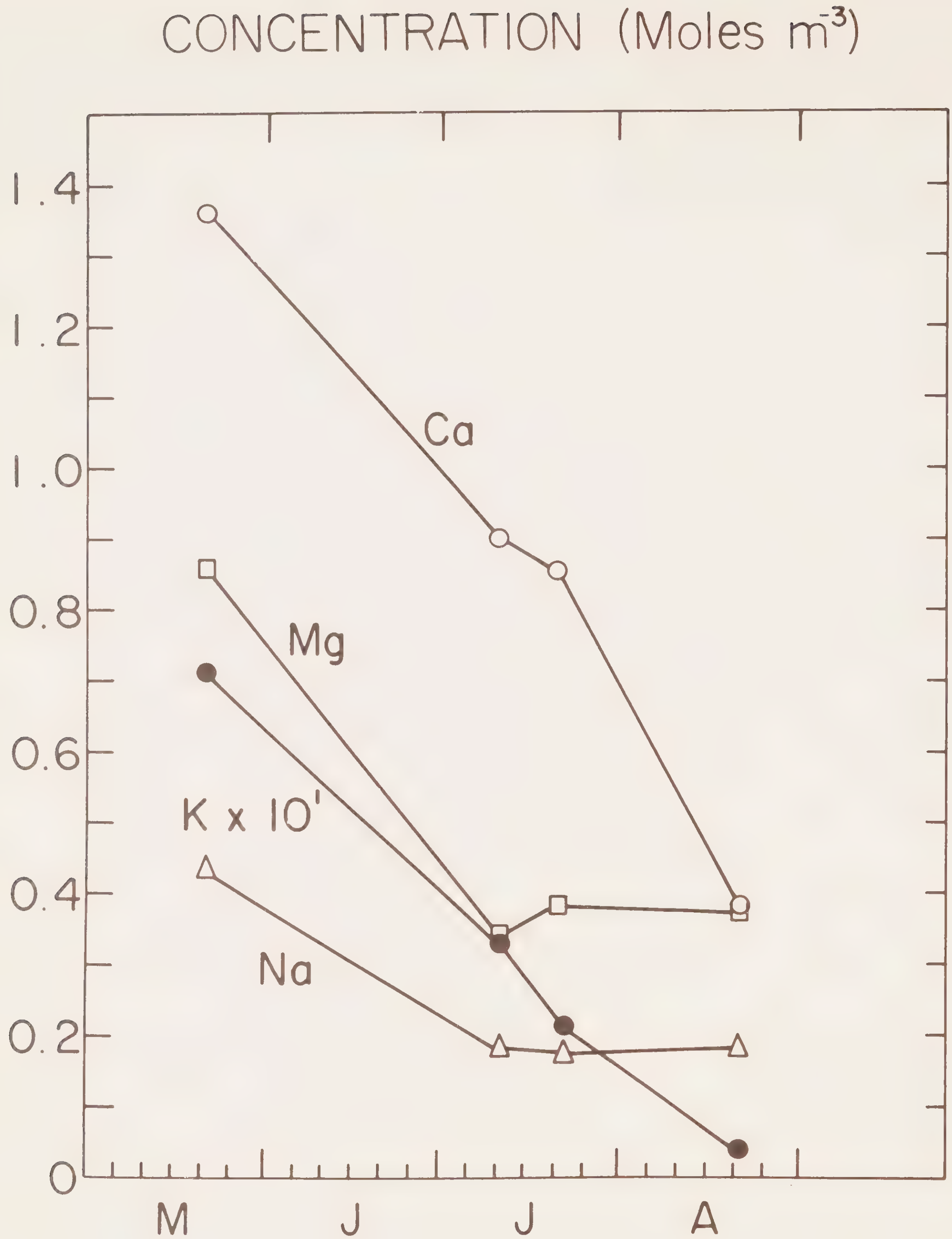


Figure 4k. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). Lake C4 (1972).

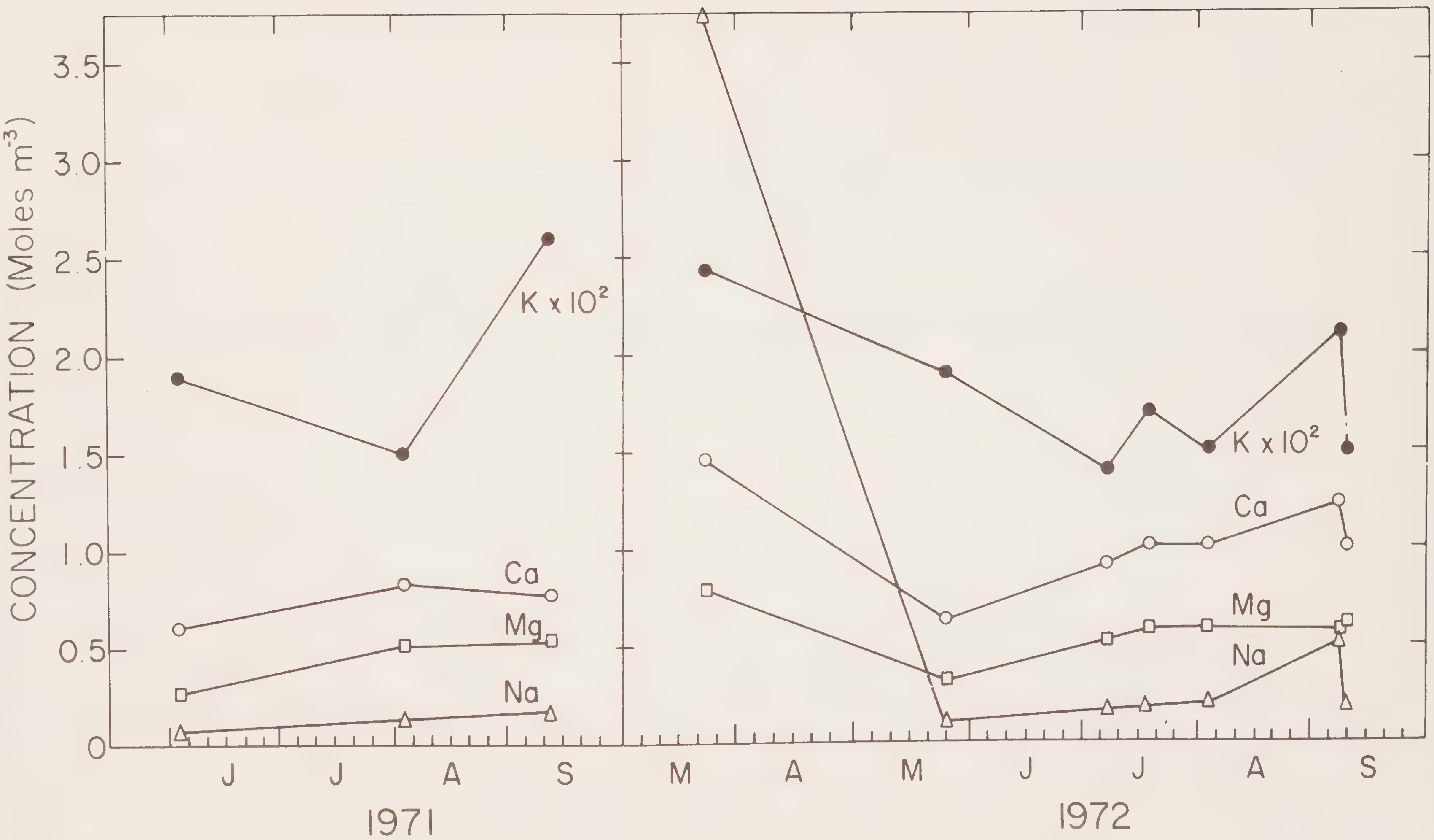


Figure 41. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). Peel River at Fort McPherson (1971-72).

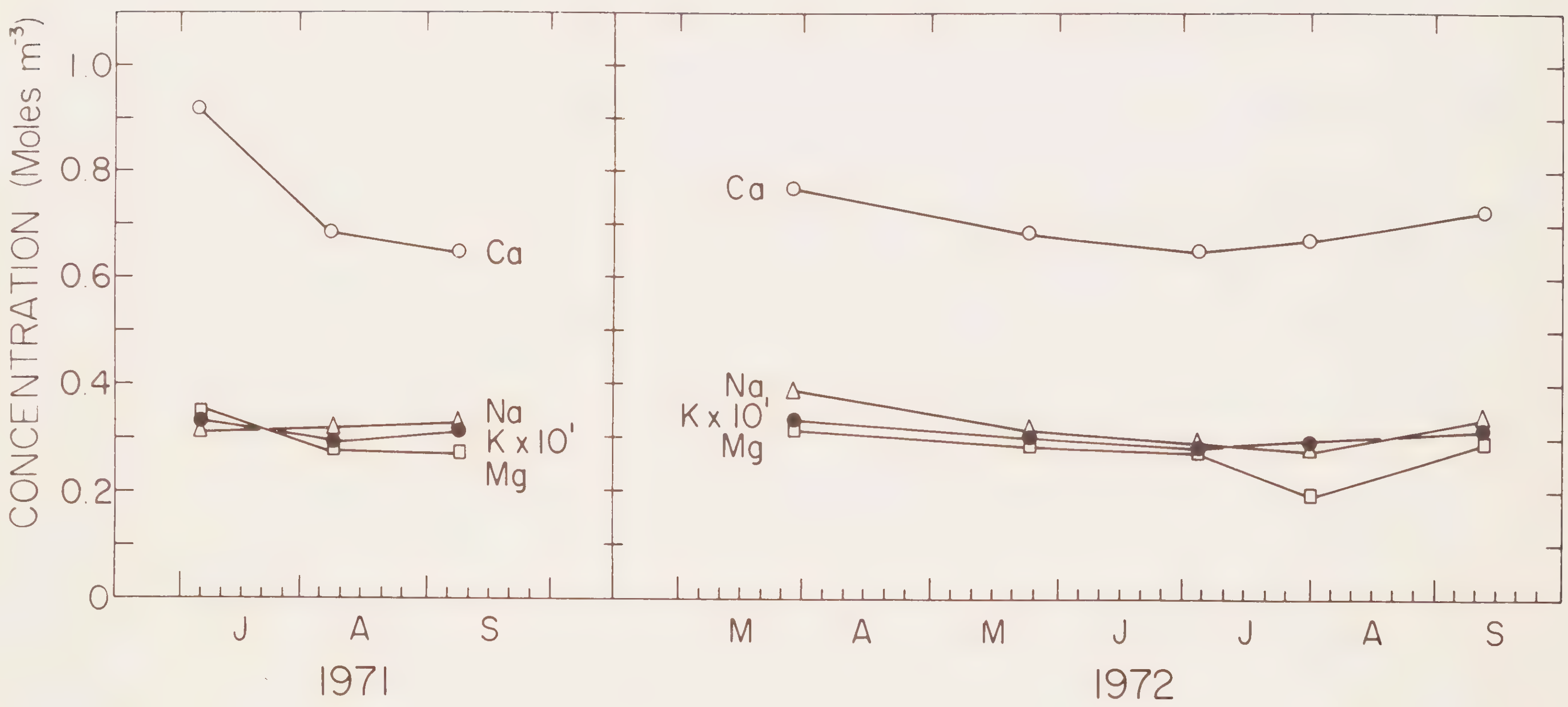


Figure 4m. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). Mackenzie River at Fort Providence (1972).

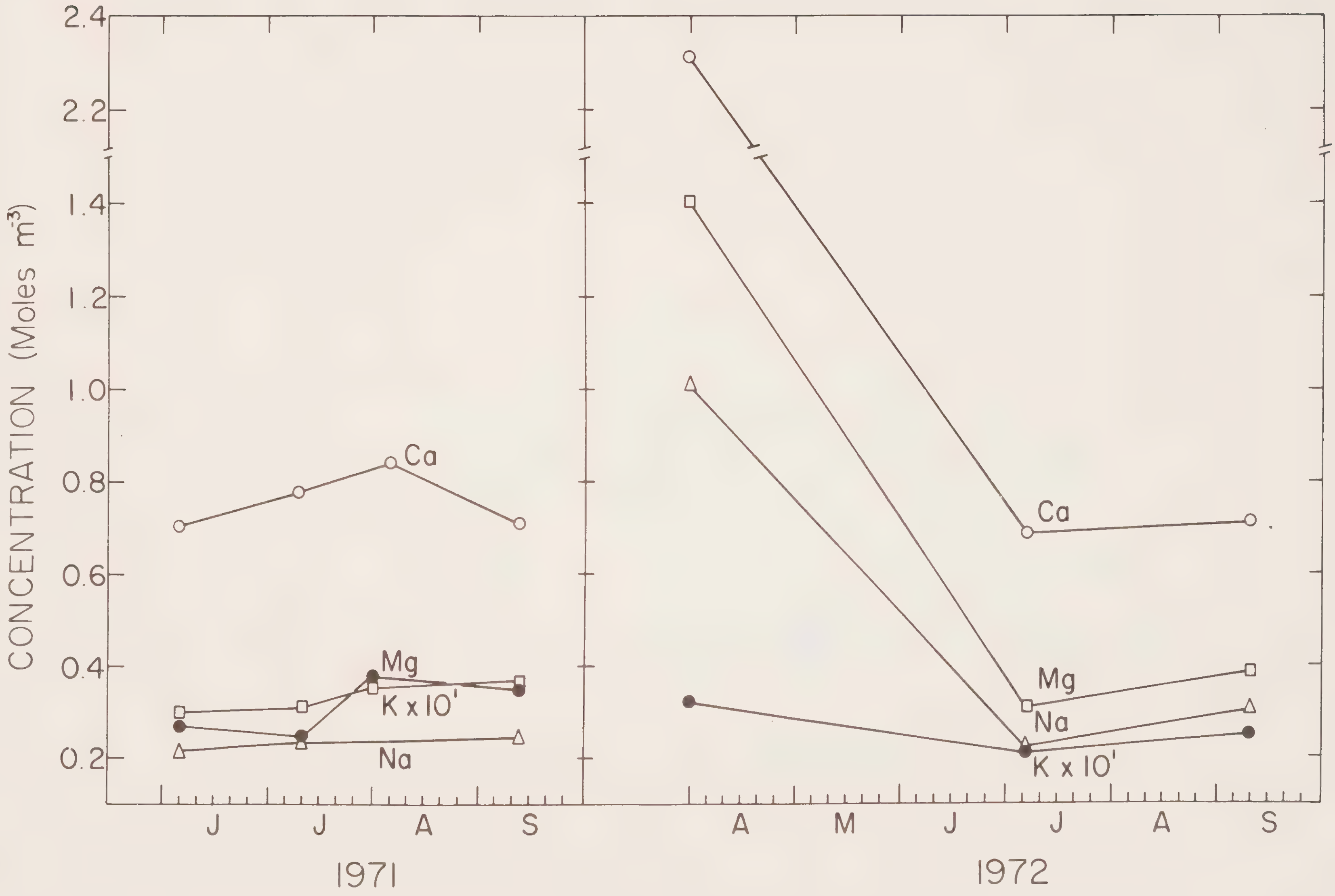


Figure 4n. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K). Mackenzie River at Norman Wells (1972).

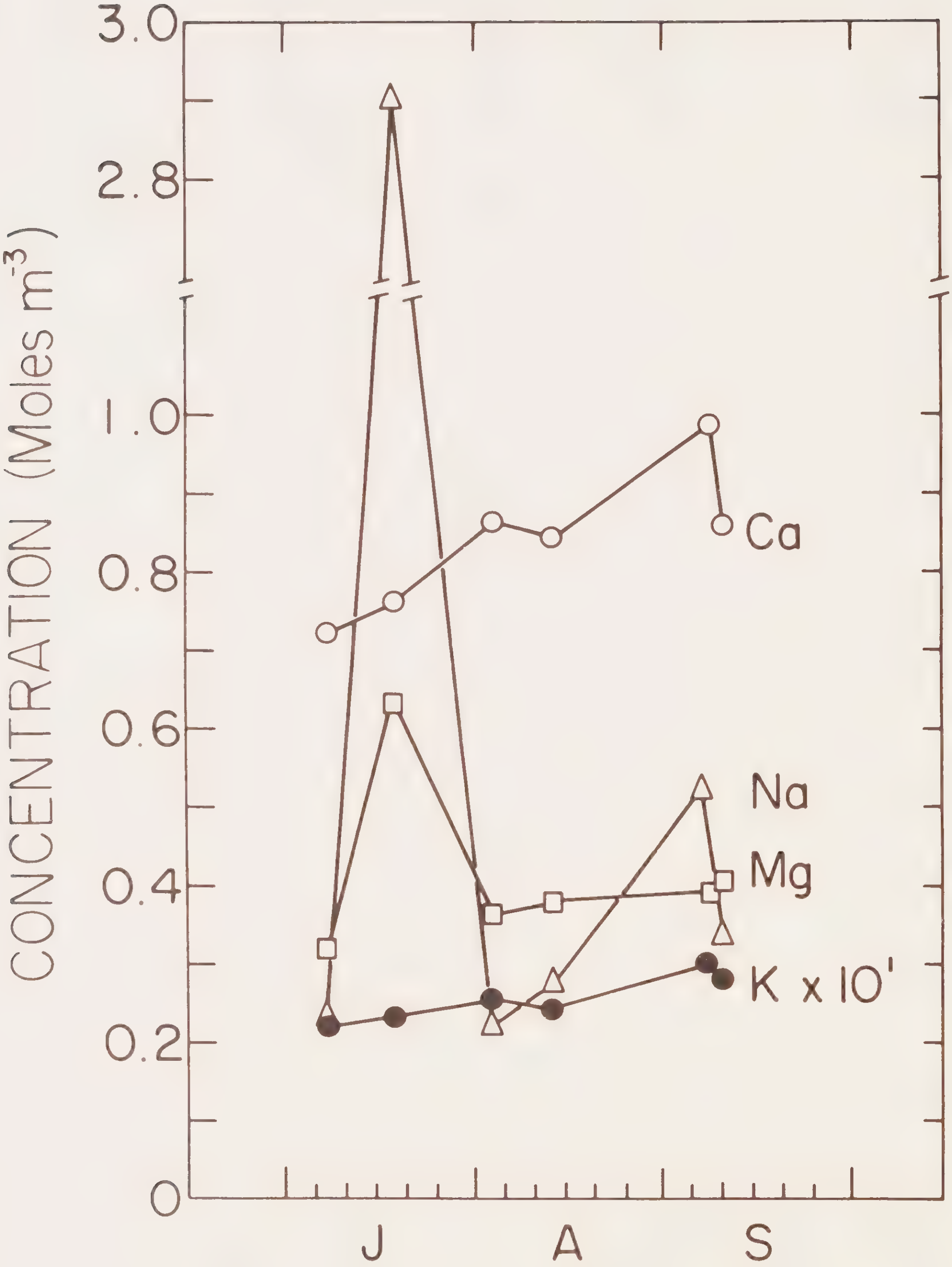


Figure 4o. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). Mackenzie River at Arctic Red River (1972).

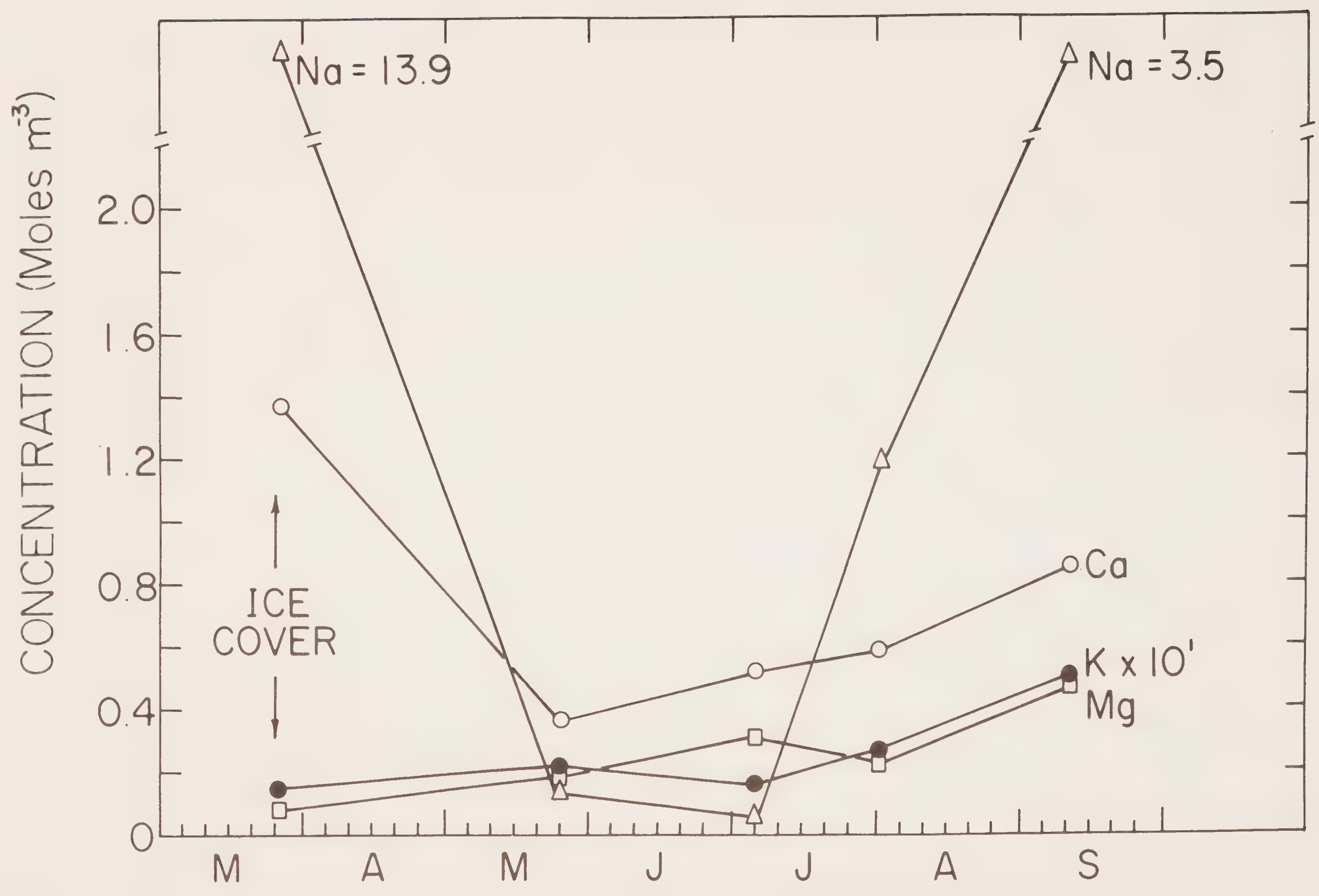


Figure 4p. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). Willowlake River (1972).

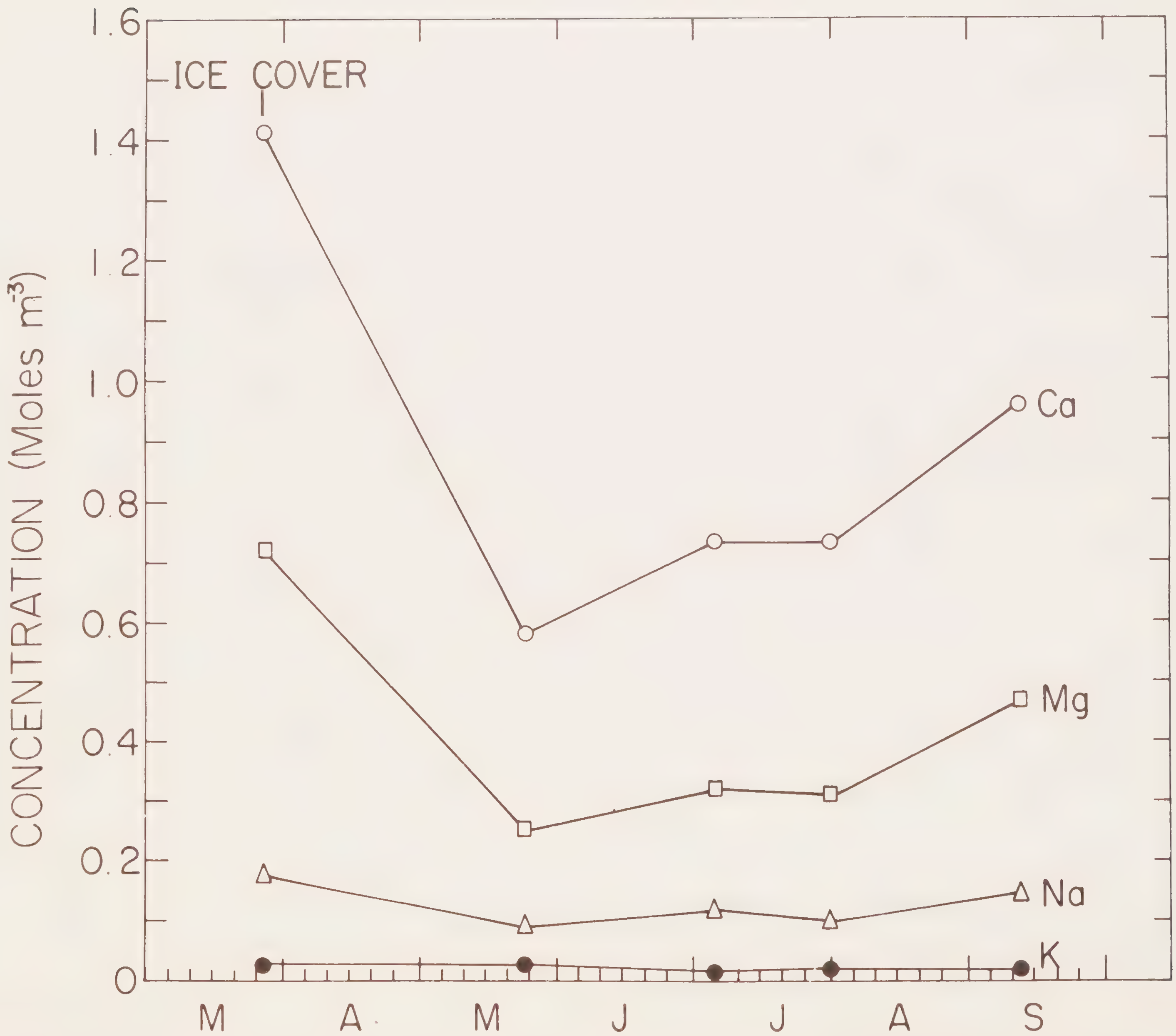


Figure 4q. Seasonal variation in concentrations of dissolved calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). Liard River at Fort Liard (1972).

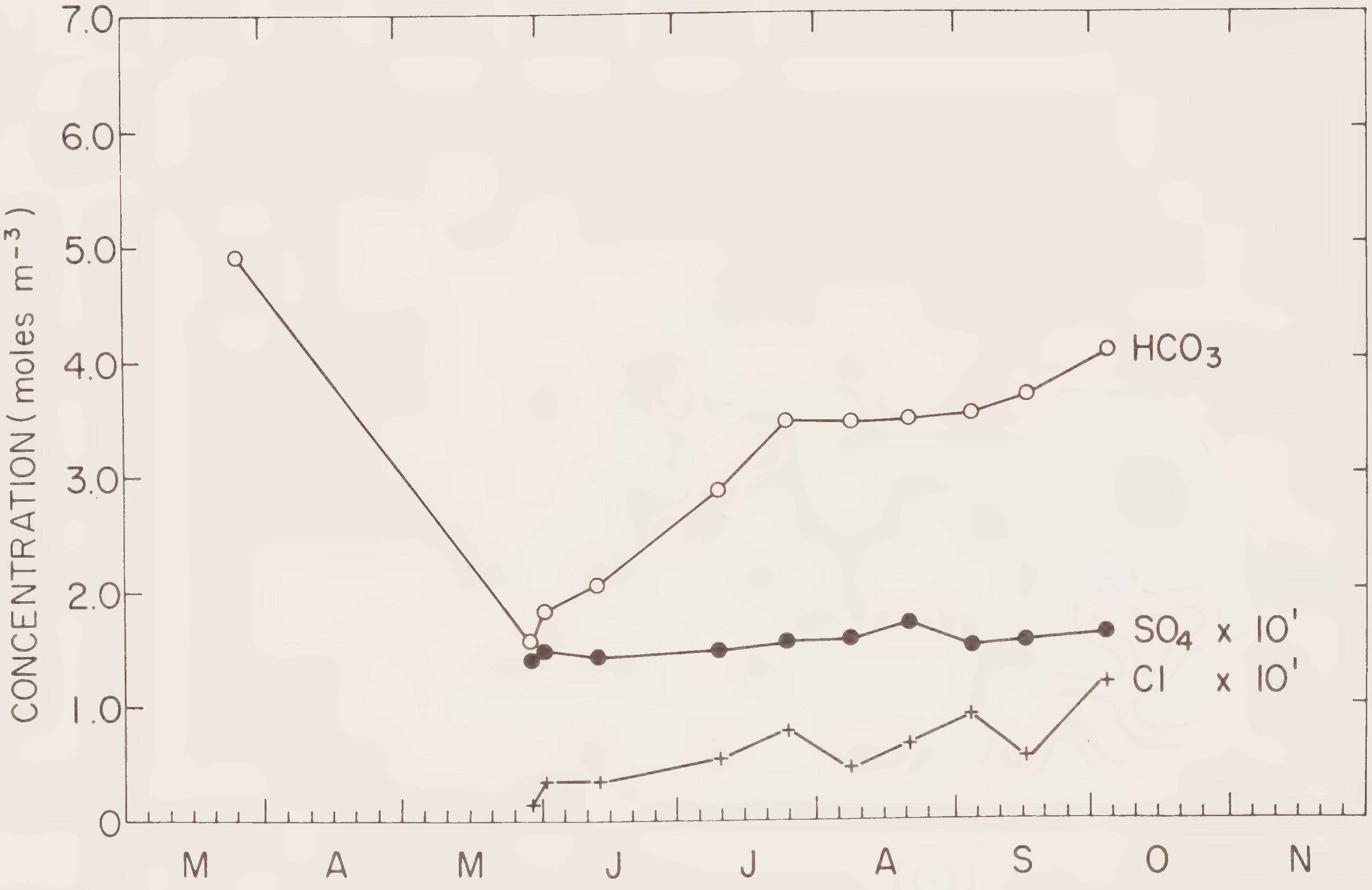


Figure 5b. Seasonal variation in concentrations of total dissolved bicarbonate (HCO_3), sulfate (SO_4) and chloride (Cl). Jean Marie Creek at Mackenzie River (1972).

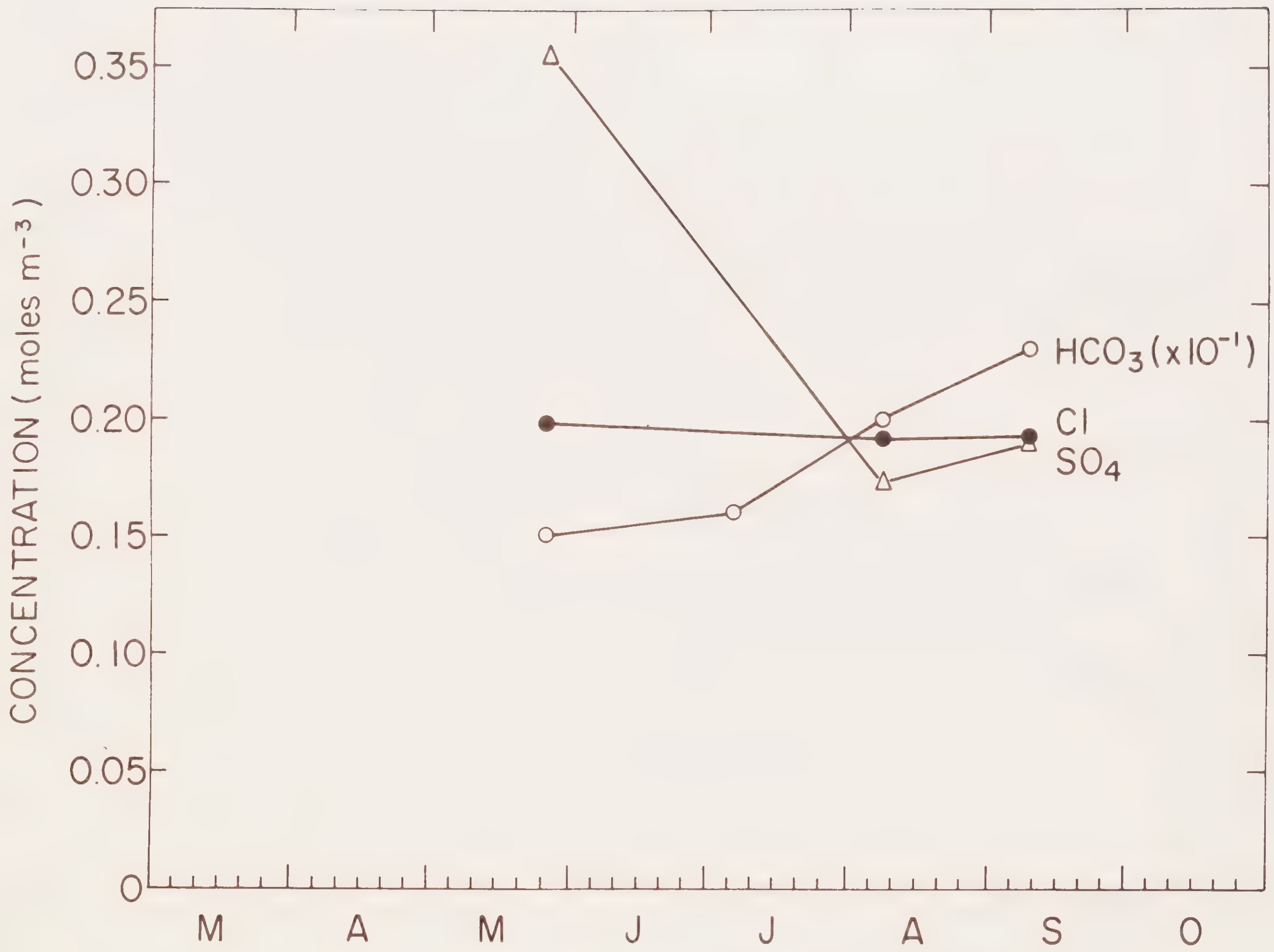


Figure 5d. Seasonal variation in concentrations of total dissolved bicarbonate (HCO_3), sulfate (SO_4) and chloride (Cl). Mackenzie River above Fort Simpson (1971).

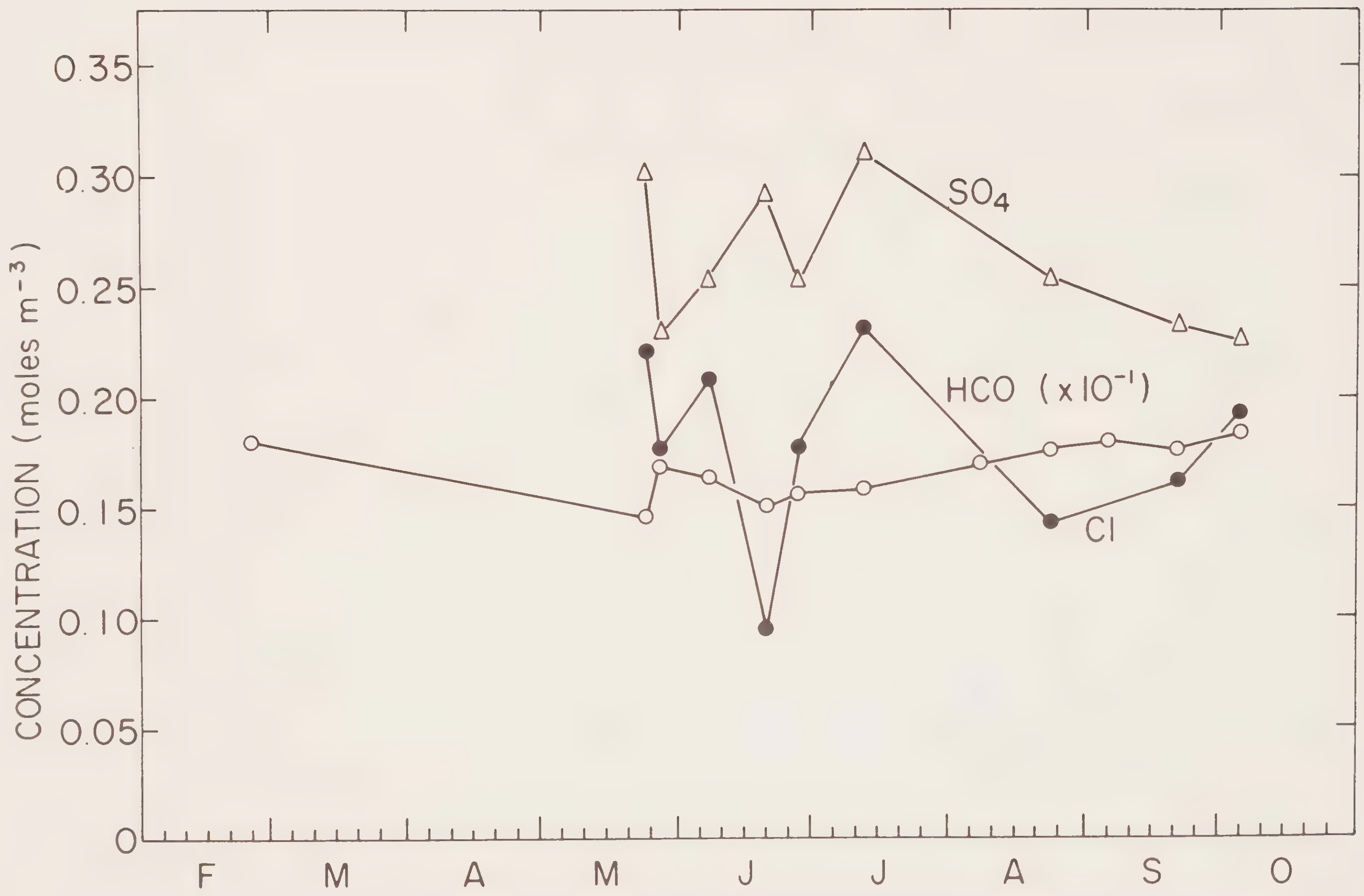


Figure 5e. Seasonal variation in concentrations of total dissolved bicarbonate (HCO_3), sulfate (SO_4) and chloride (Cl). Mackenzie River above Fort Simpson (1972).

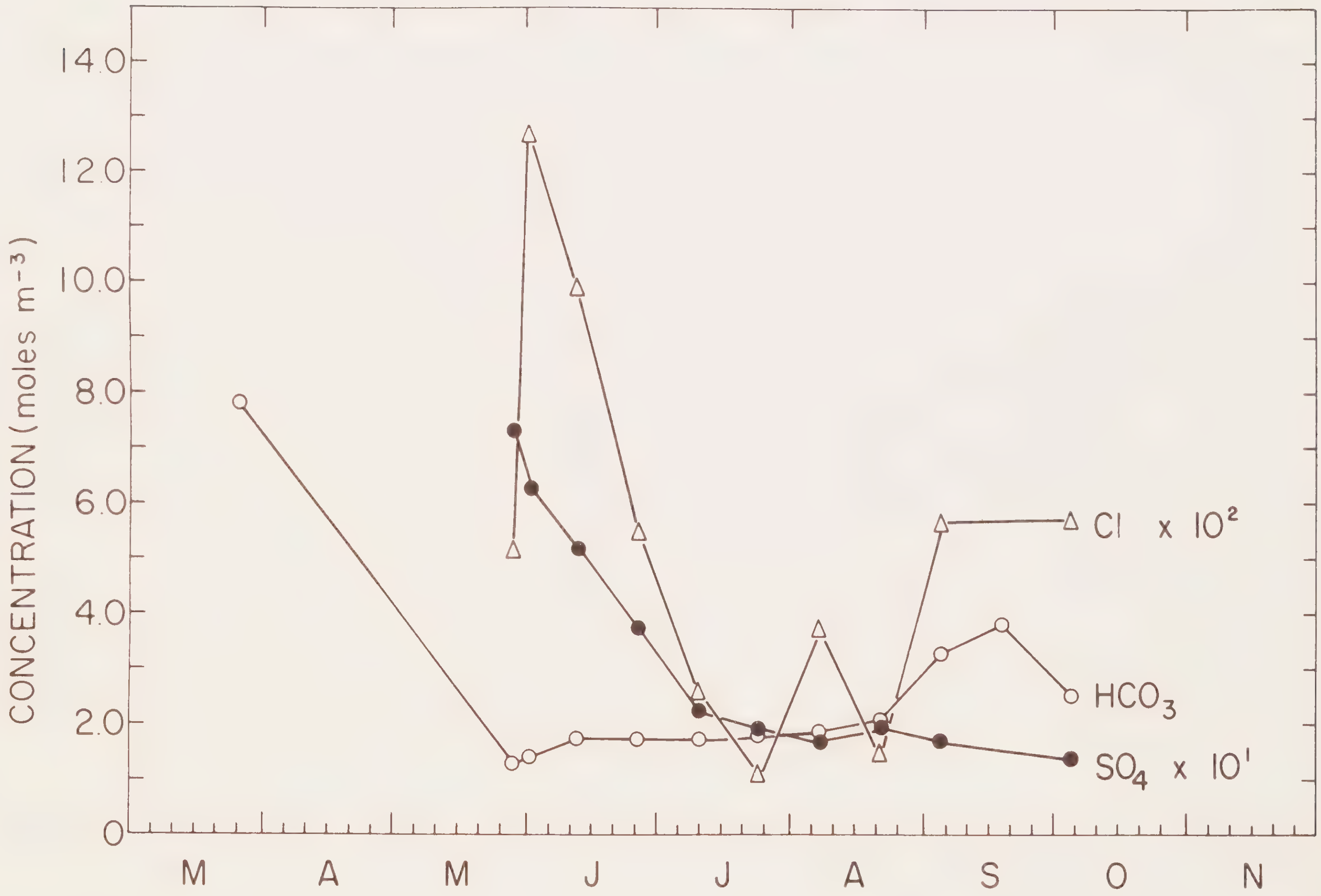


Figure 5g. Seasonal variation in concentrations of total dissolved bicarbonate (HCO_3), sulfate (SO_4) and chloride (Cl). Rabbitskin River at Mackenzie River (1972).

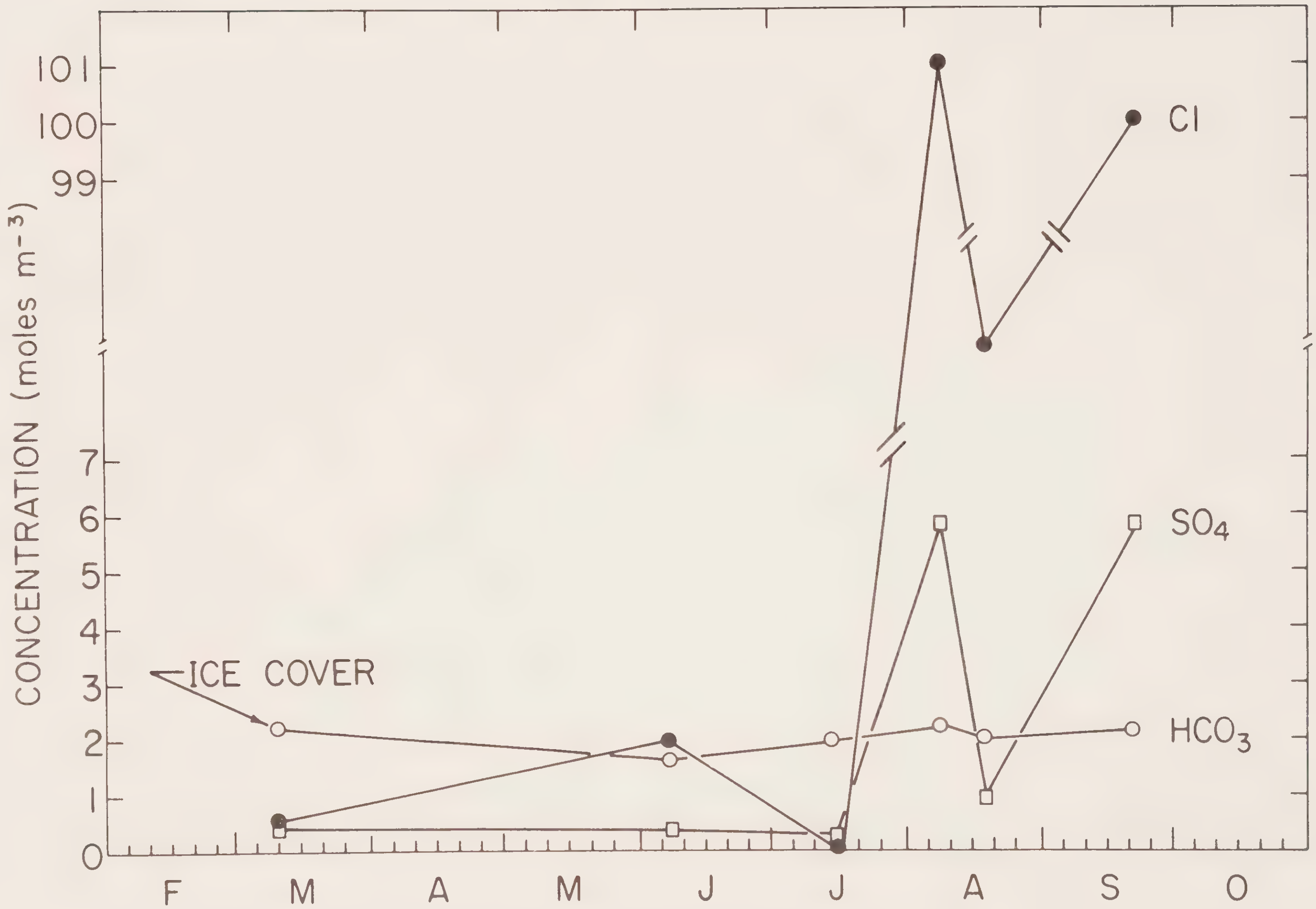


Figure 5i. Seasonal variation in concentrations of total dissolved bicarbonate (HCO_3), sulfate (SO_4) and chloride (Cl). Kugmallit Bay - KU4 (1972).

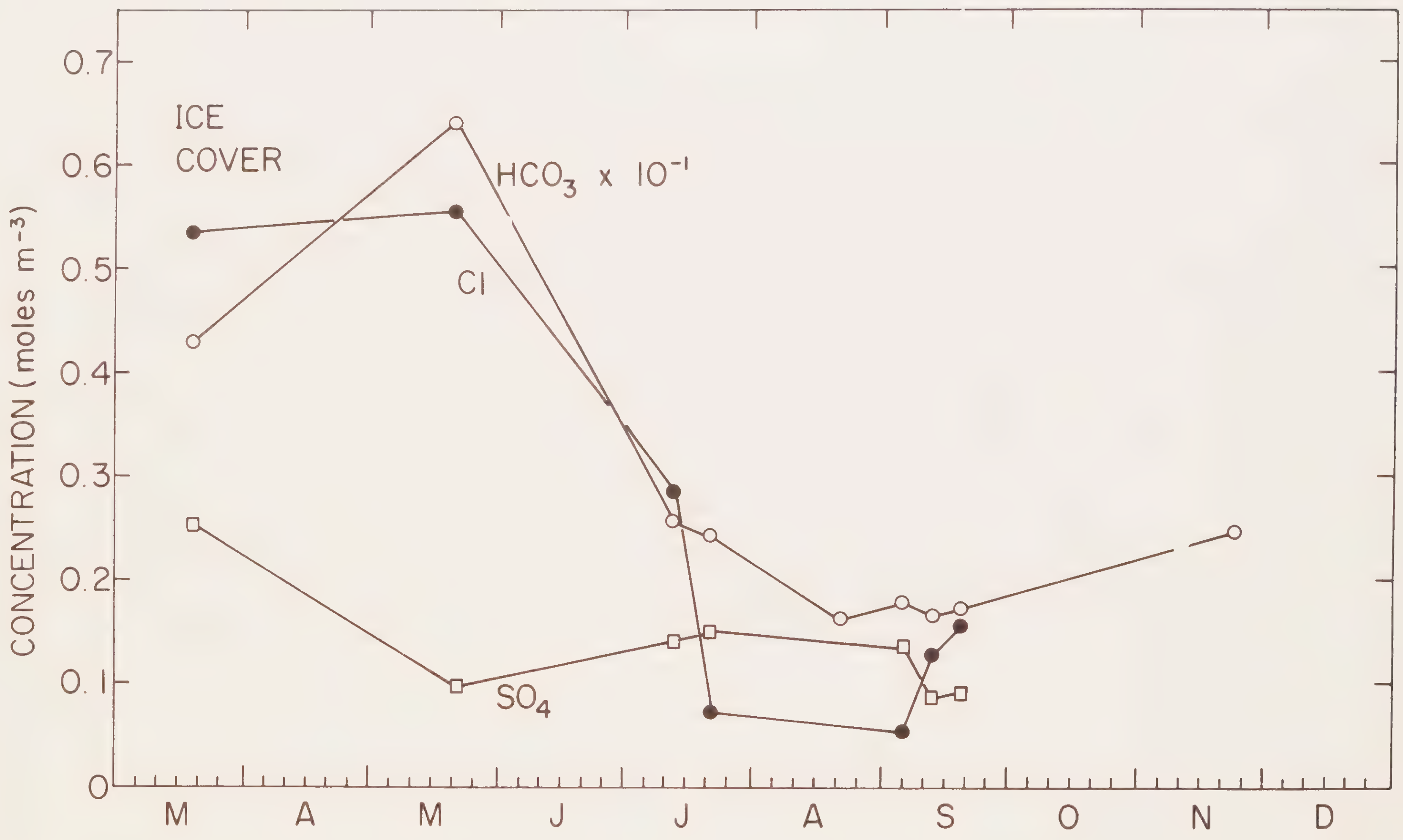


Figure 5j. Seasonal variation in concentrations of total dissolved bicarbonate (HCO_3), sulfate (SO_4) and chloride (Cl). Lake 4 (1972).

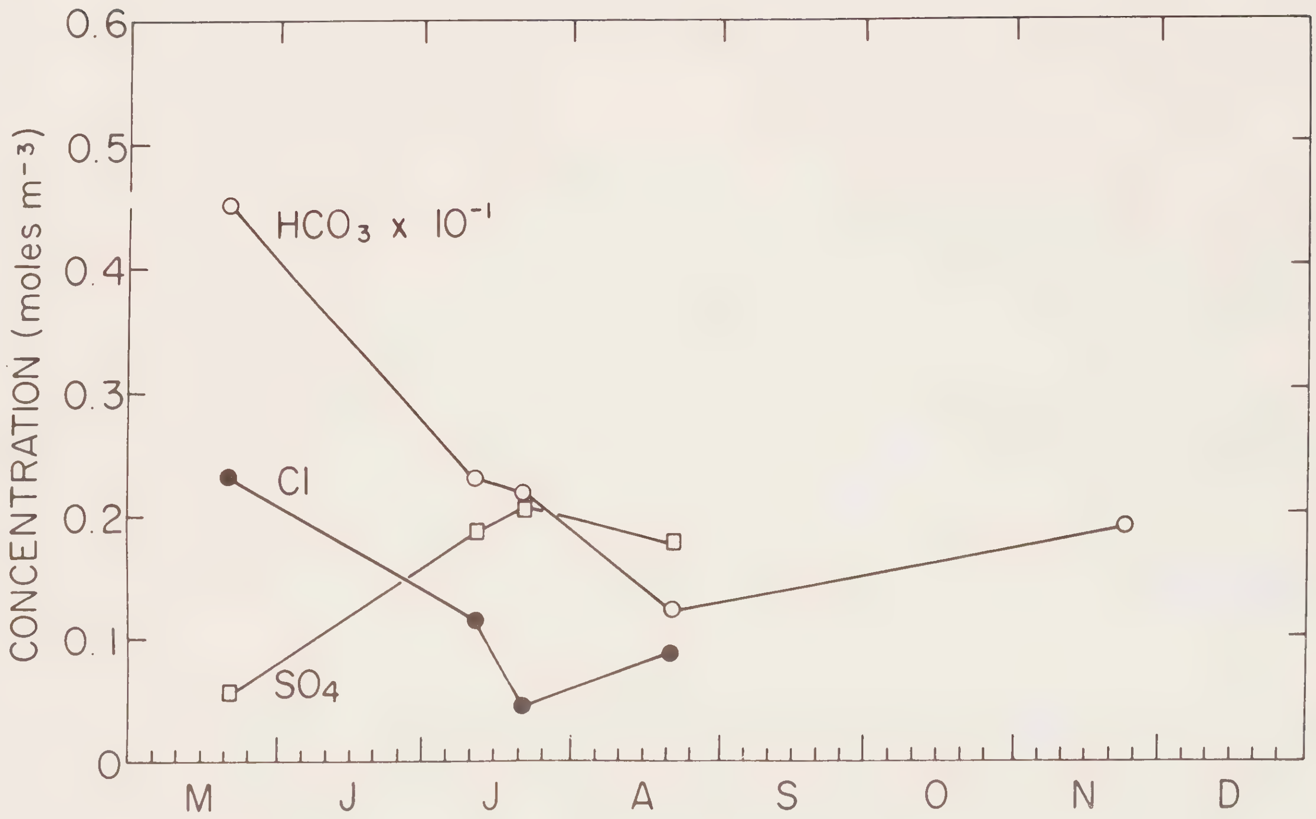


Figure 5k. Seasonal variation in concentrations of total dissolved bicarbonate (HCO_3), sulfate (SO_4) and chloride (Cl). Lake C4 (1972).

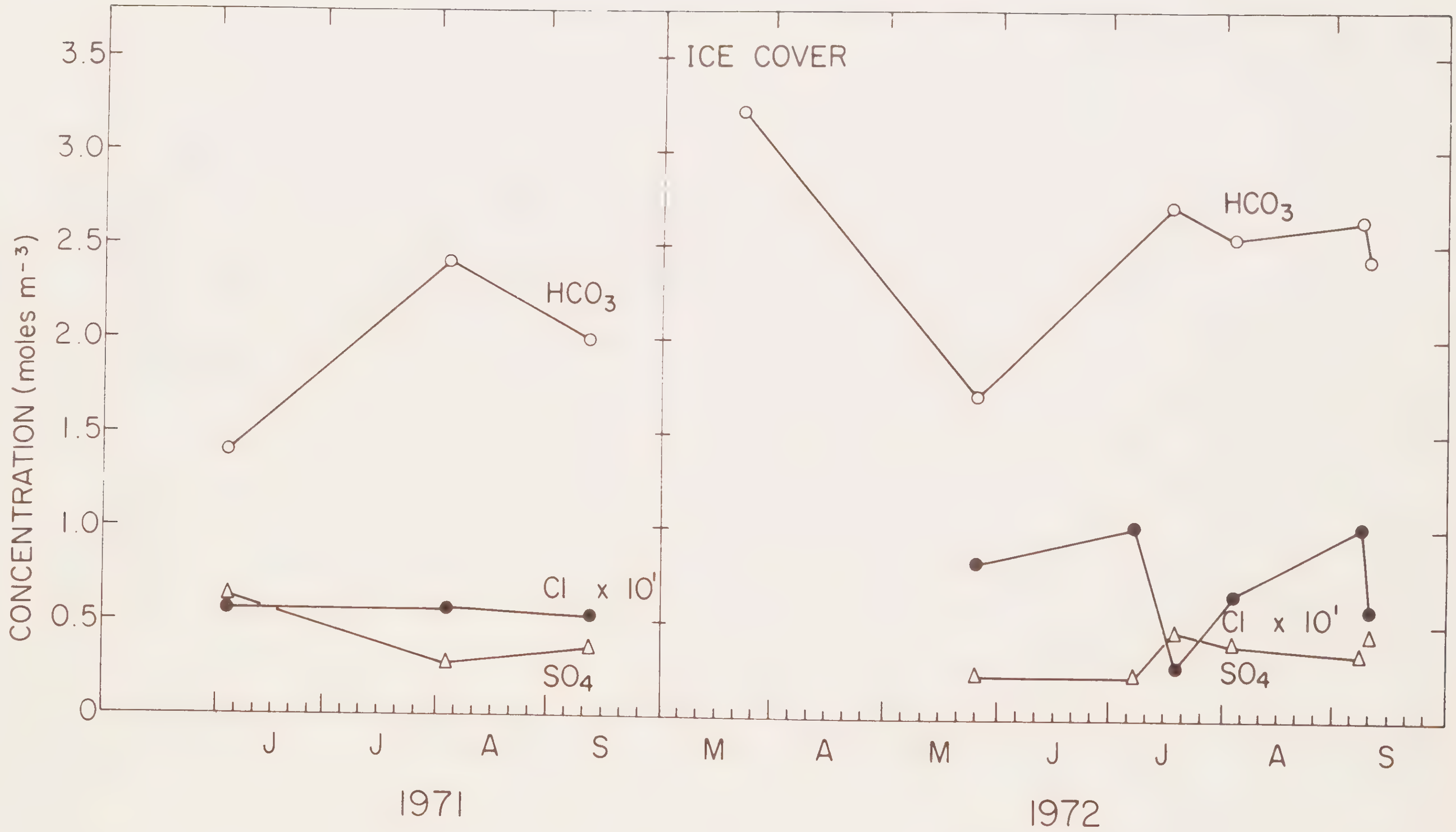


Figure 51. Seasonal variation in concentrations of total dissolved bicarbonate (HCO_3), sulfate (SO_4) and chloride (Cl). Peel River at Fort McPherson (1971-72).

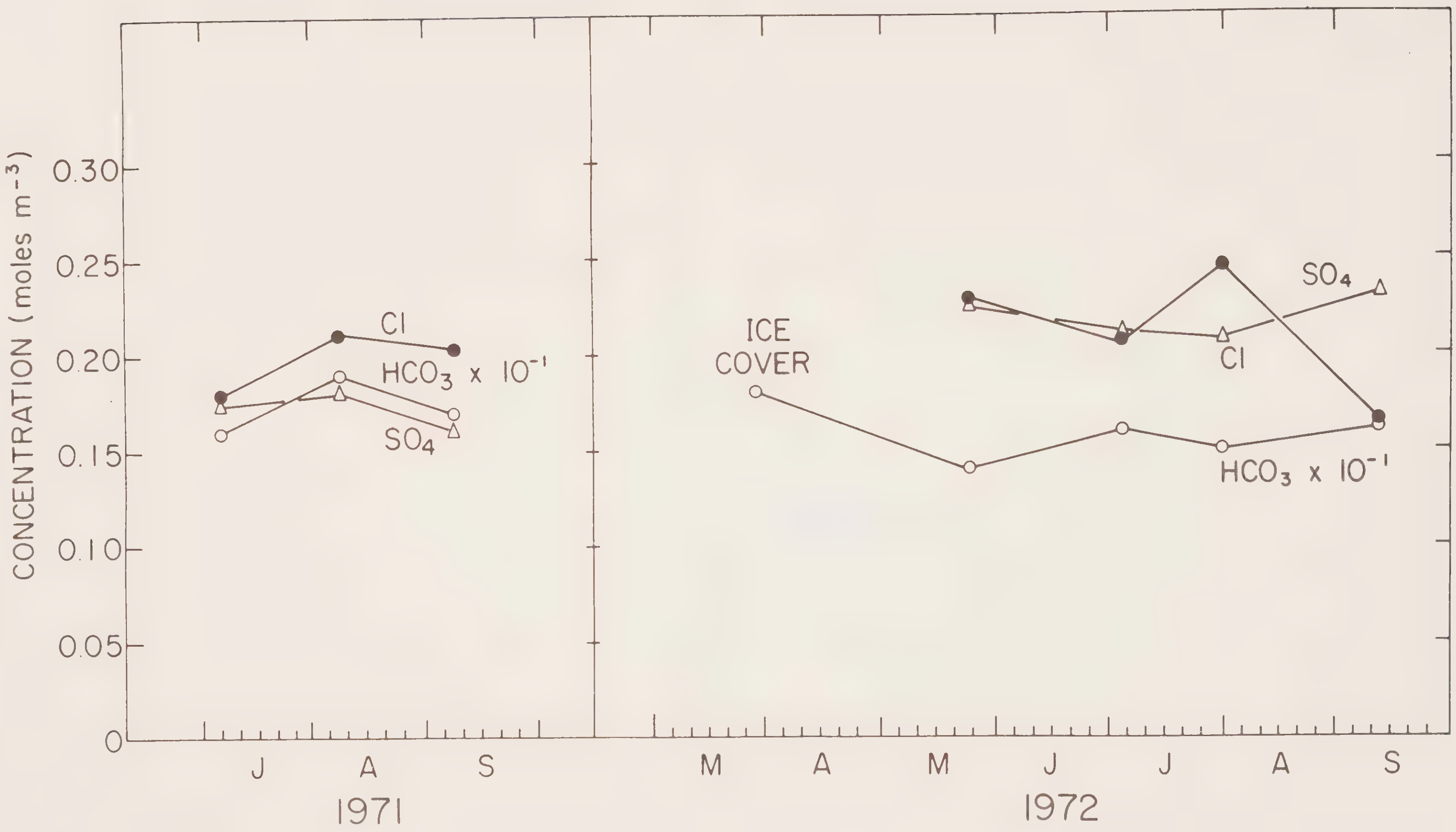


Figure 5m. Seasonal variation in concentrations of total dissolved bicarbonate (HCO_3), sulfate (SO_4) and chloride (Cl). Mackenzie River at Fort Providence (1972).

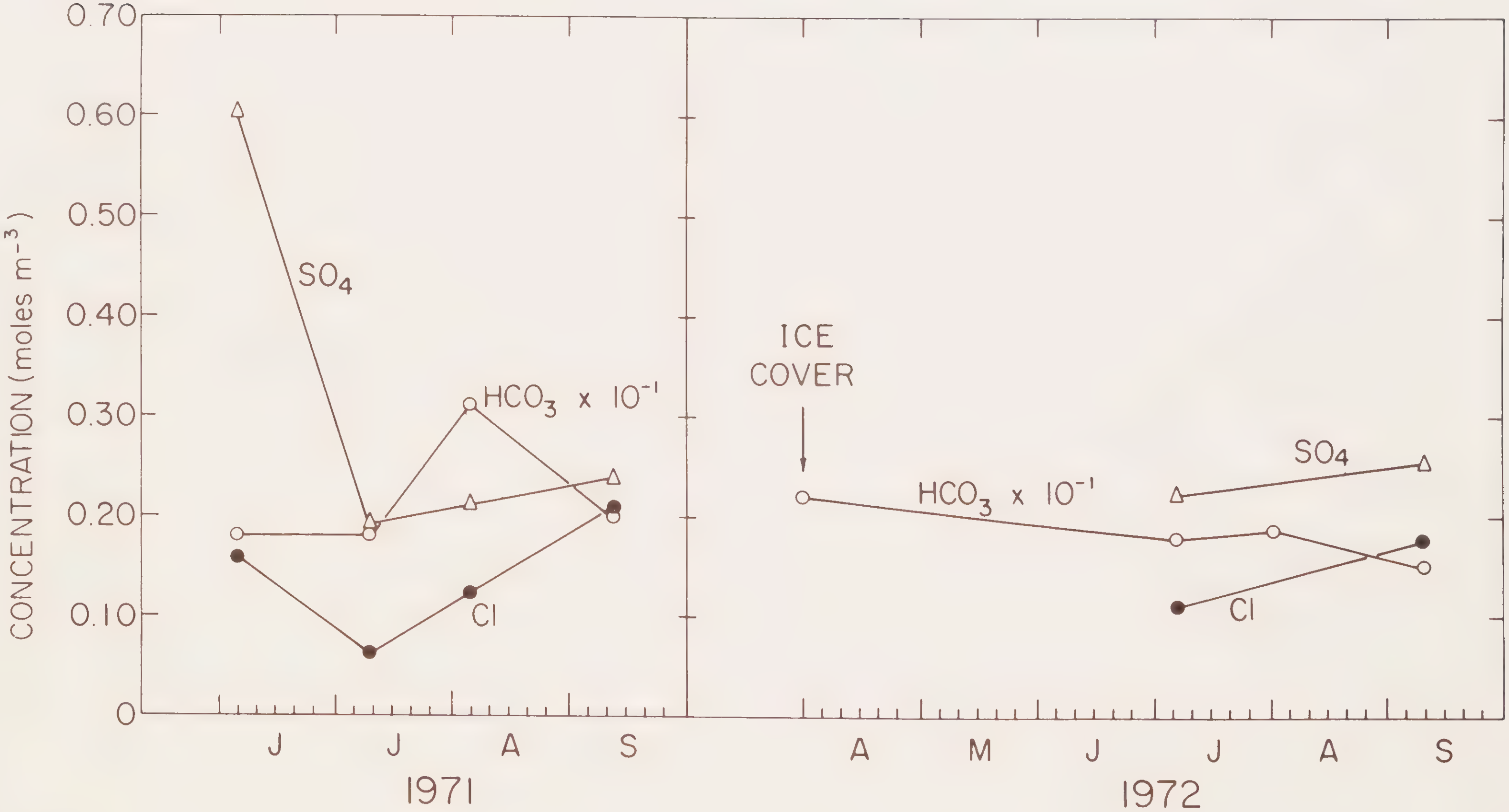


Figure 5n. Seasonal variation in concentrations of total dissolved bicarbonate (HCO_c), sulfate (SO_4) and chloride (Cl). Mackenzie River at Norman Wells (1972).

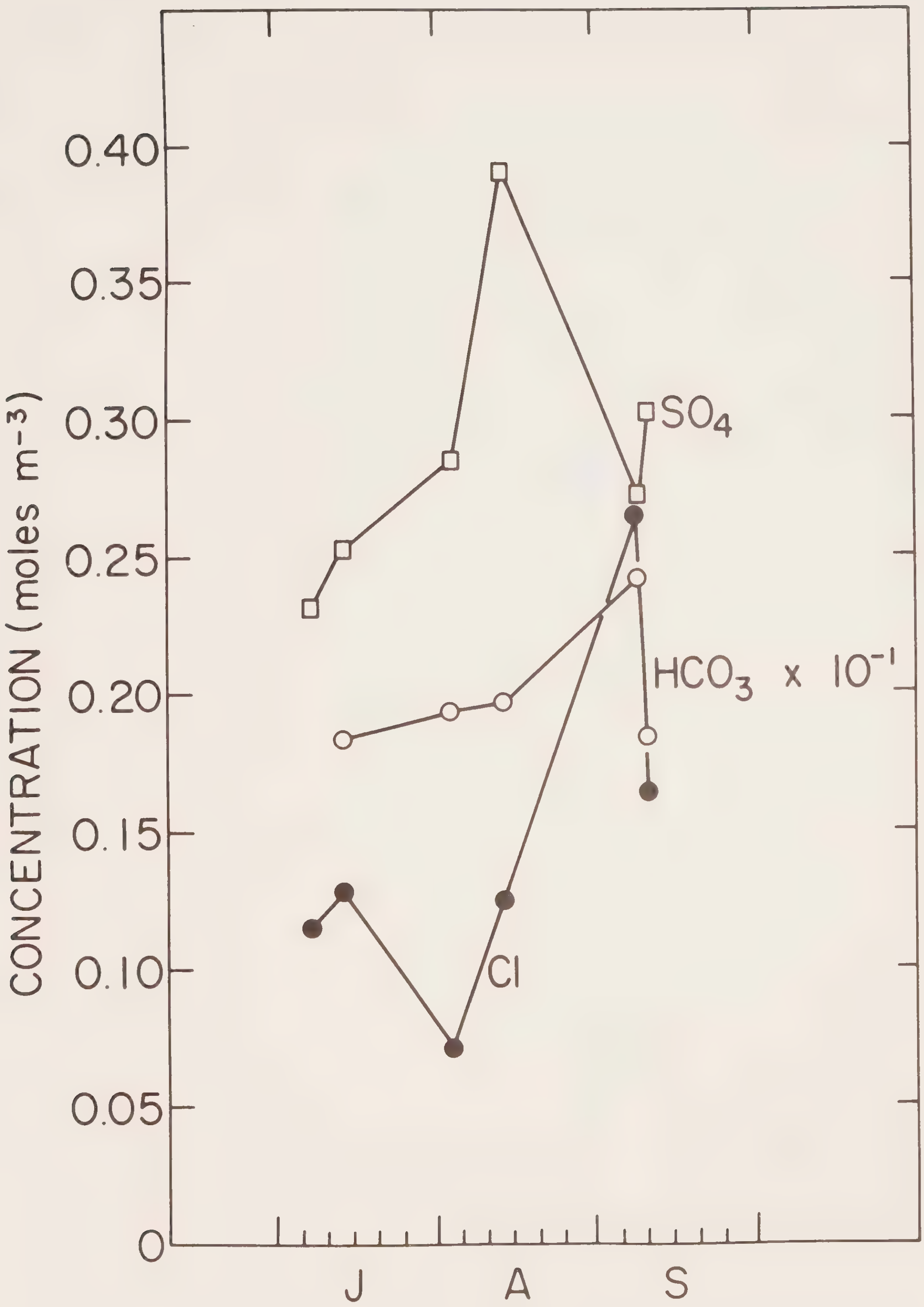


Figure 5o. Seasonal variation in concentrations of total dissolved bicarbonate (HCO_3) sulfate (SO_4) and chloride (Cl). Mackenzie River at Arctic Red River (1972).

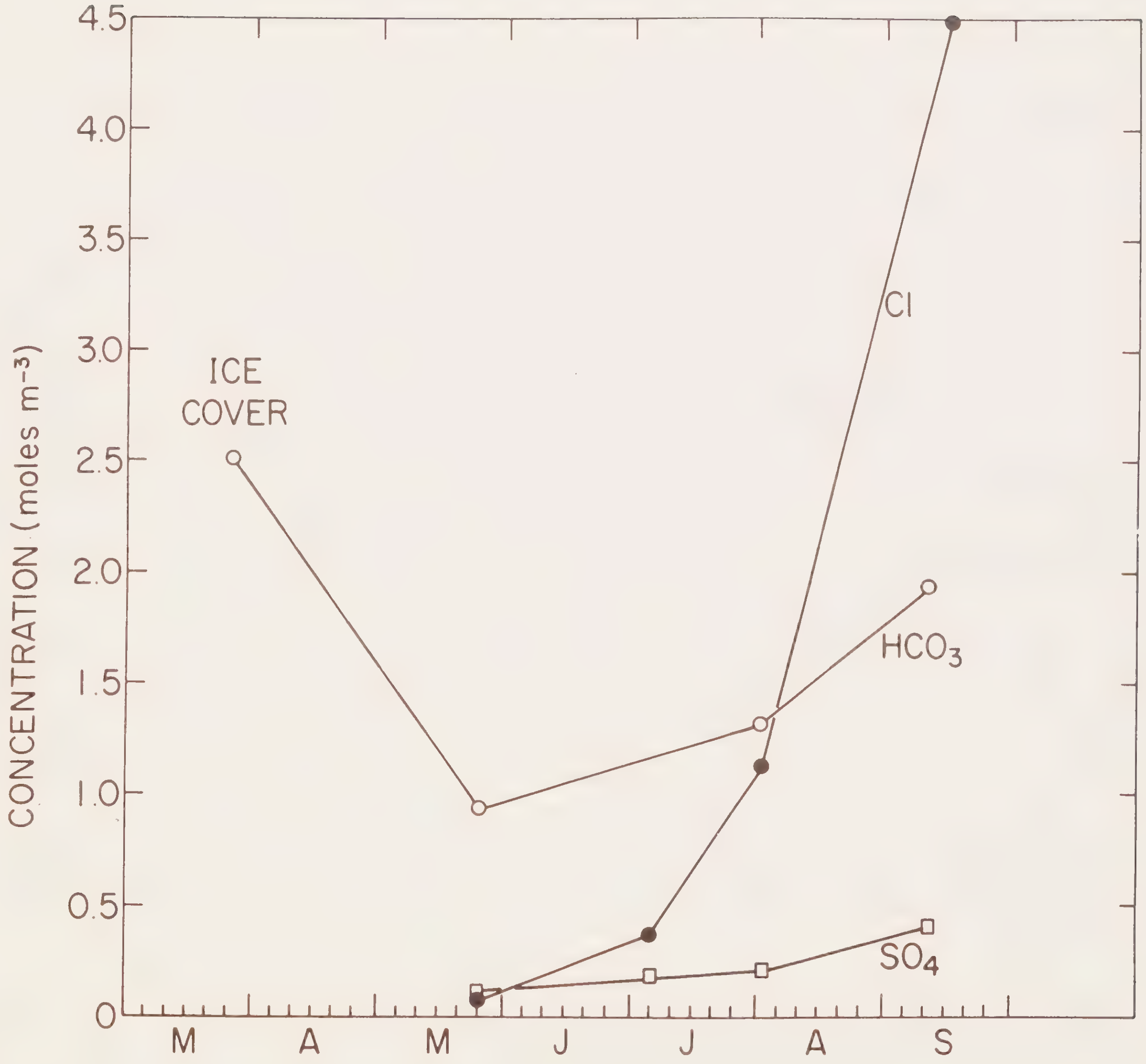


Figure 5p. Seasonal variation in concentrations of total dissolved bicarbonate (HCO_3), sulfate (SO_4) and chloride (Cl). Willowlake River (1972).

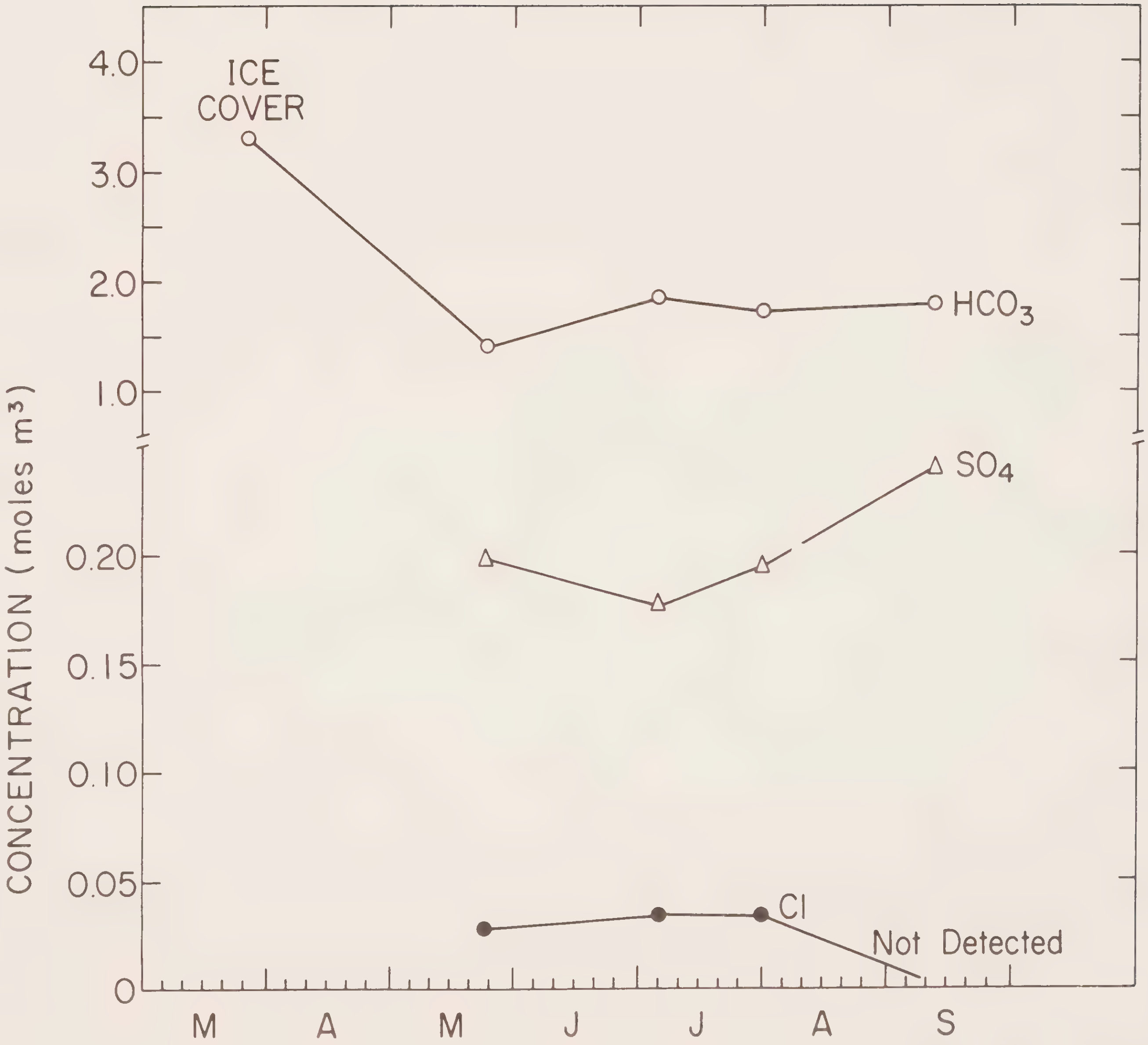


Figure 5q. Seasonal variation in concentrations of total dissolved bicarbonate (HCO_3), sulfate (SO_4) and chloride (Cl). Liard River at Fort Liard (1972).

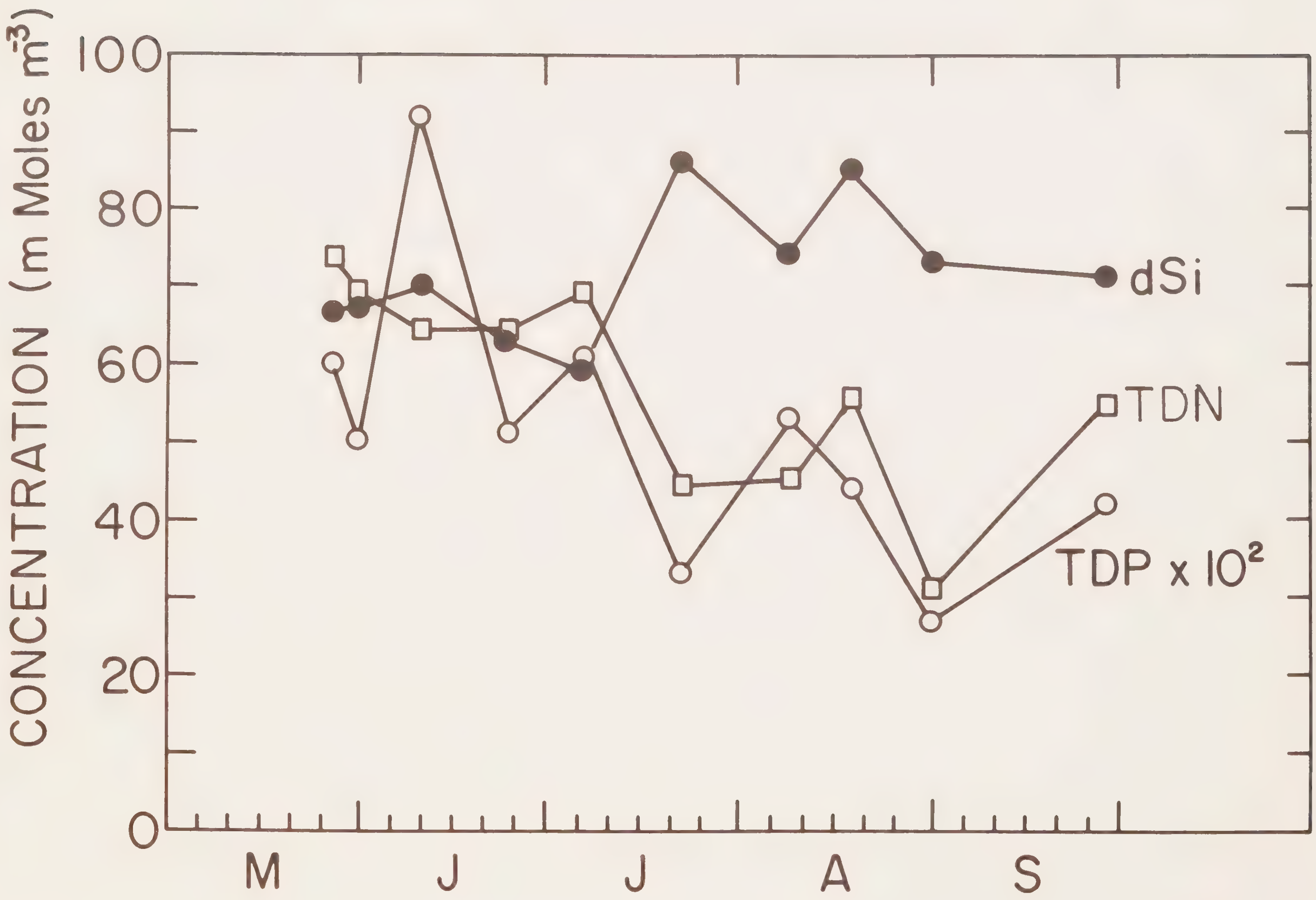


Figure 6a. Seasonal variation in concentrations of total dissolved nitrogen (TDN), phosphorus (TDP), and silica (Si). Harris River at Mackenzie River (1972).

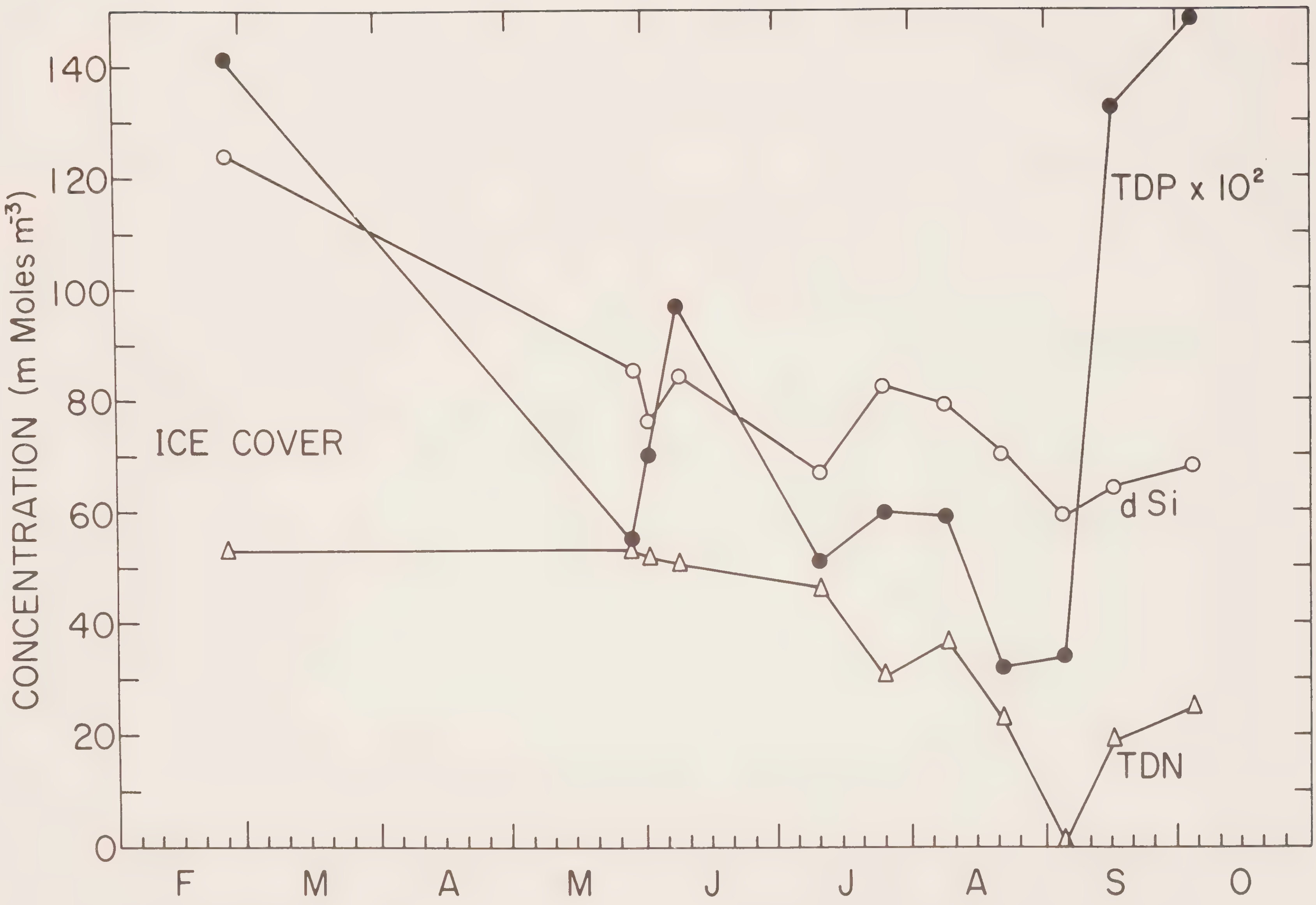


Figure 6b. Seasonal variation in concentrations of total dissolved nitrogen (TDN), phosphorus (TDP) and silica (Si). Jean Marie Creek at Mackenzie River (1972).

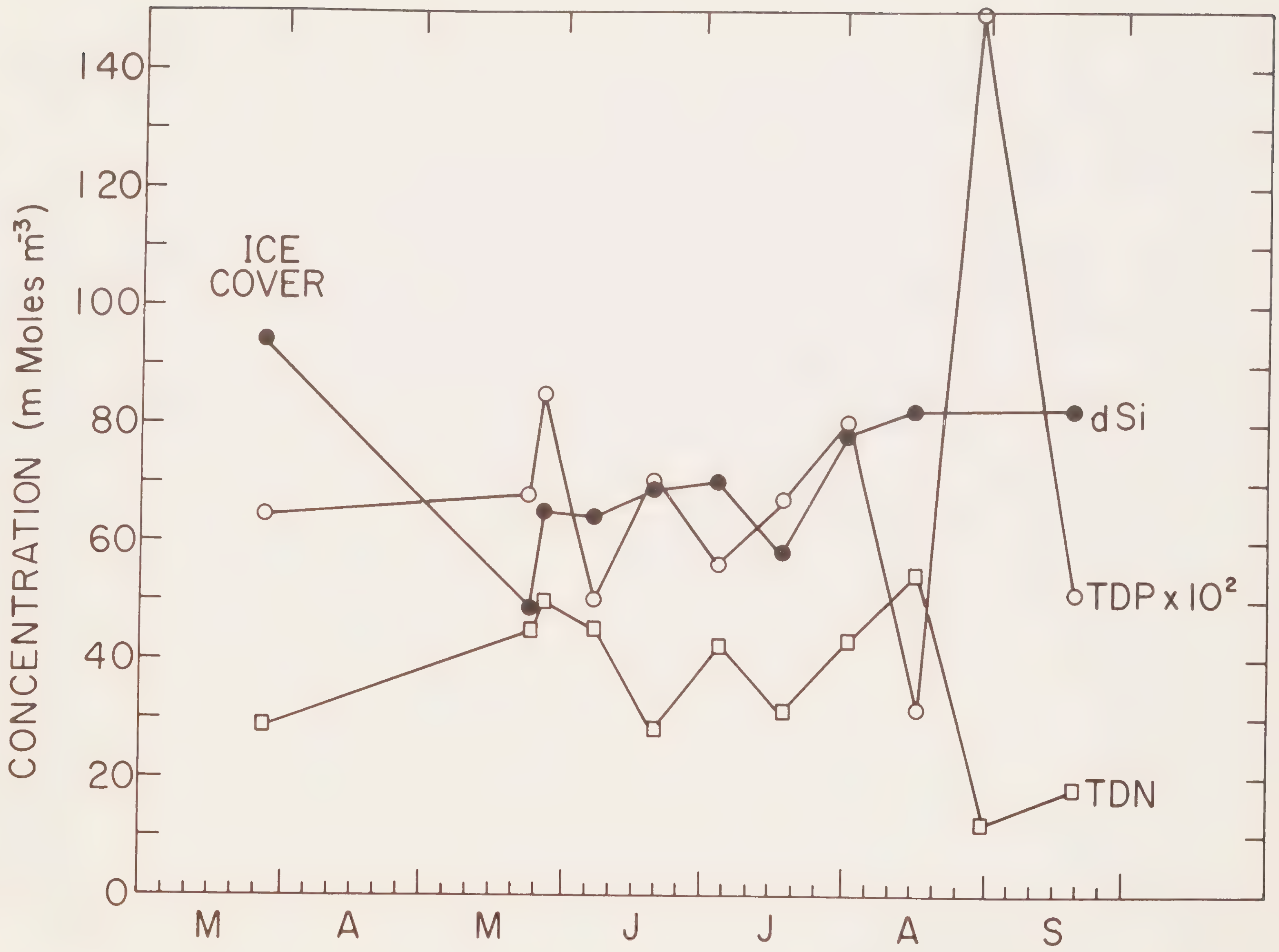


Figure 6c. Seasonal variation in concentrations of total dissolved nitrogen (TDN), phosphorus (TDP), and silica (Si). Liard River at Fort Simpson (1972).

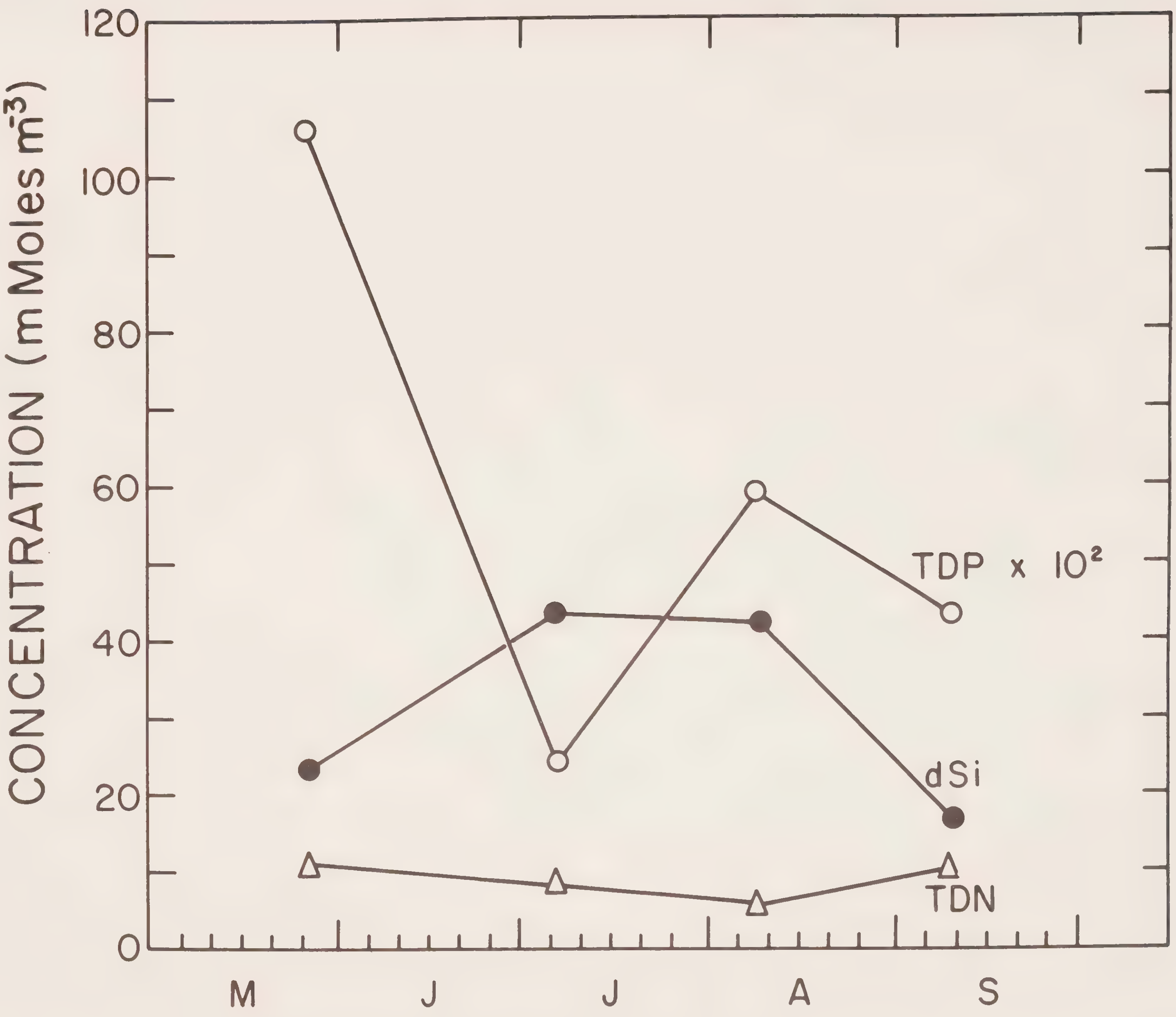


Figure 6d. Seasonal variation in concentrations of total dissolved nitrogen (TDN), phosphorus (TDP), and silica (Si). Mackenzie River above Fort Simpson (1971).

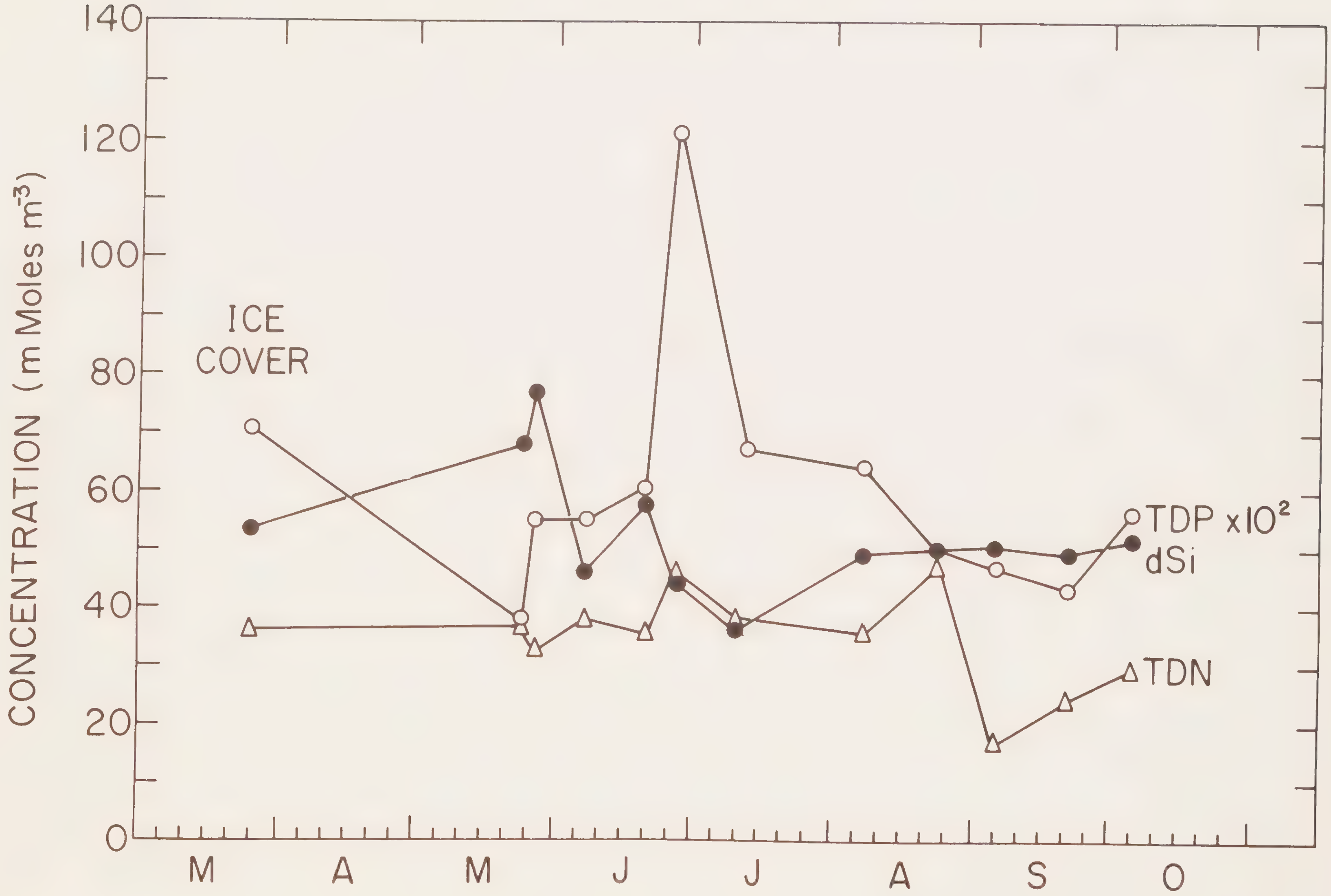


Figure 6e. Seasonal variation in concentrations of total dissolved nitrogen (TDN), phosphorus (TDP), and silica (Si). Mackenzie River above Fort Simpson (1972).

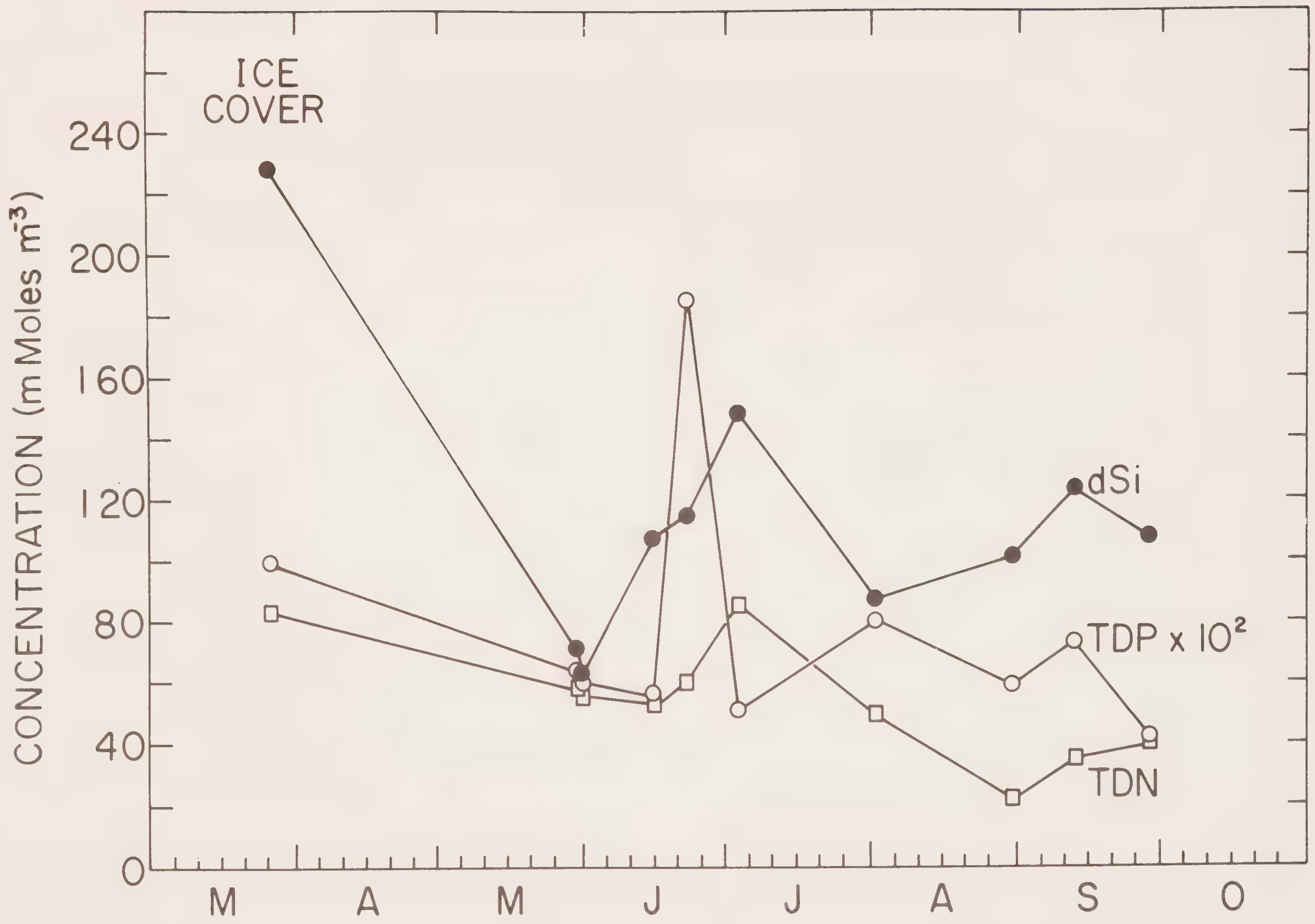


Figure 6f. Seasonal variation in concentrations of total dissolved nitrogen (TDN), phosphorus (TDP), and silica (Si). Martin River at Mackenzie River (1972).

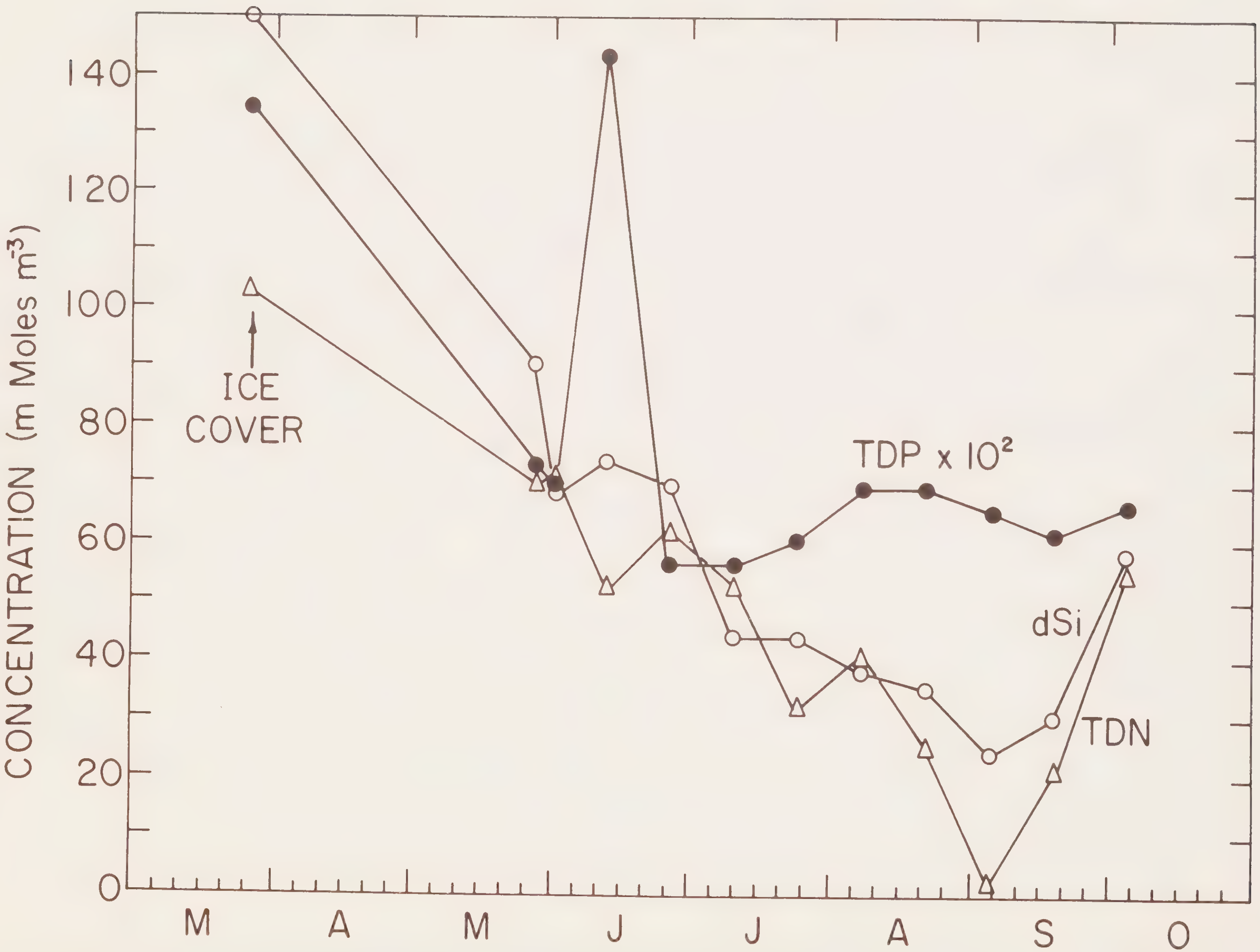


Figure 6g. Seasonal variation in concentrations of total dissolved nitrogen (TDN), phosphorus (TDP), and silica (Si), Rabbitskin River at Mackenzie River (1972).

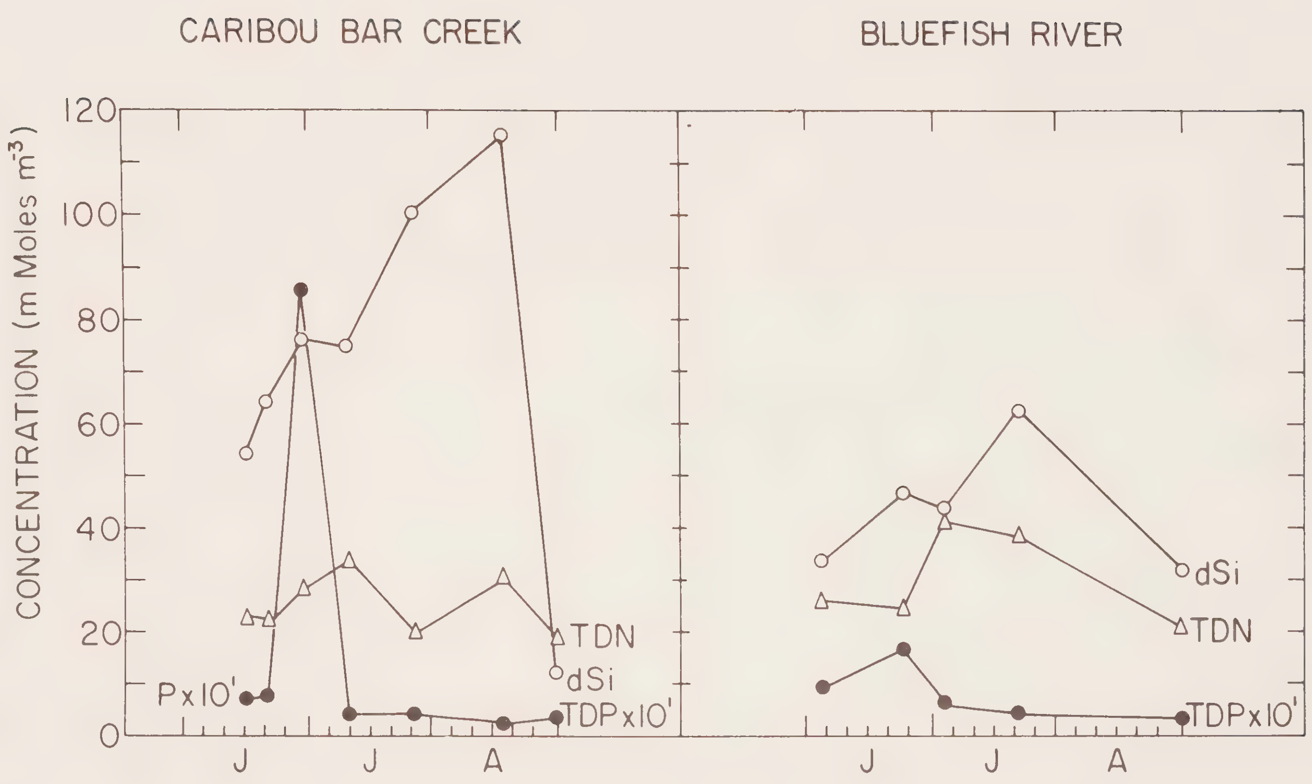


Figure 6h. Seasonal variation in concentrations of total dissolved nitrogen (TDN), phosphorus (TDP), and silica (Si). **Bluefish** River and Caribou Bar Creek (1972).

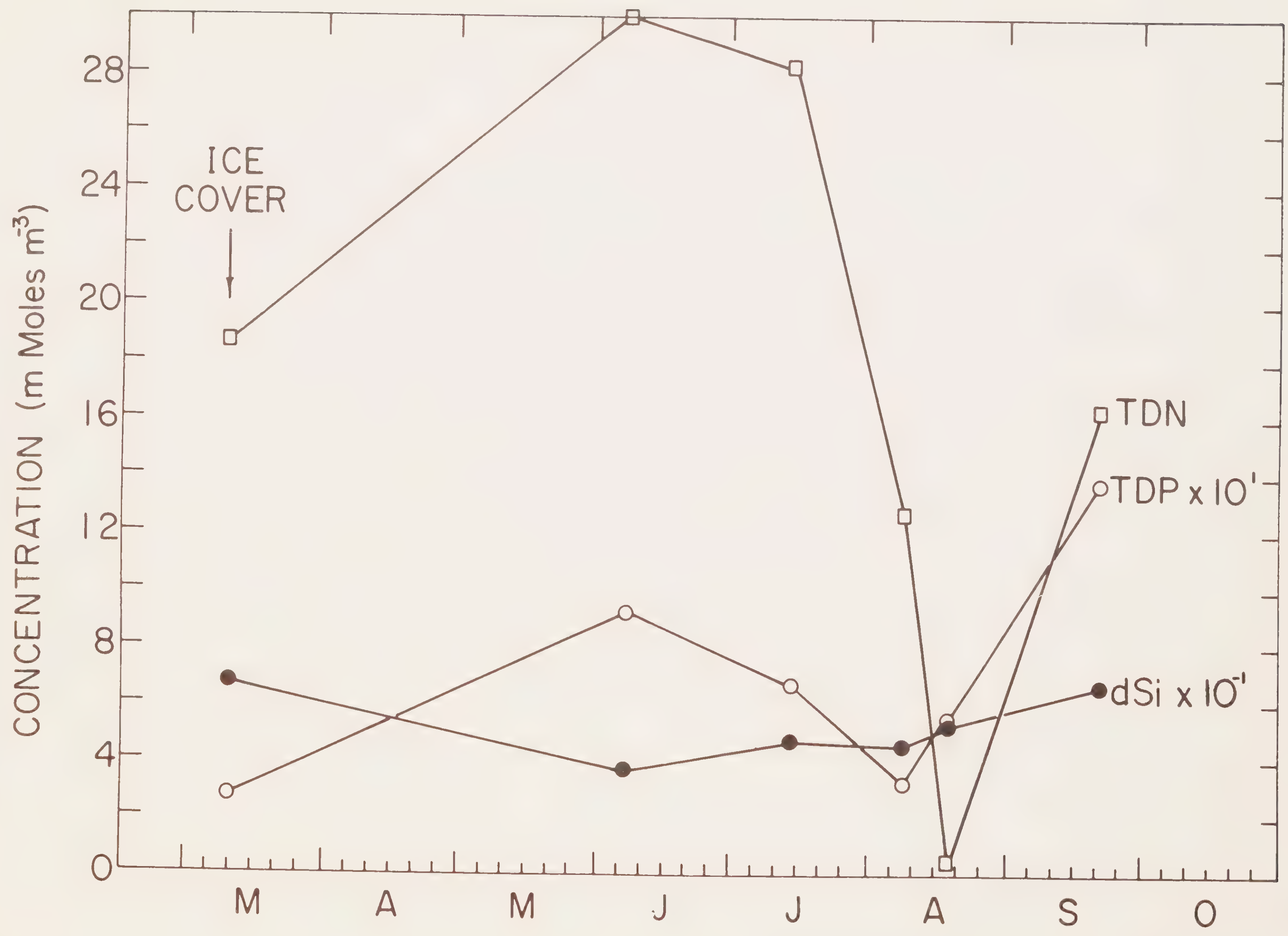


Figure 6i. Seasonal variation in concentrations of total dissolved nitrogen (TDN), phosphorus (TDP), and silica (Si). Kugmallit Bay - KU4 (1972).

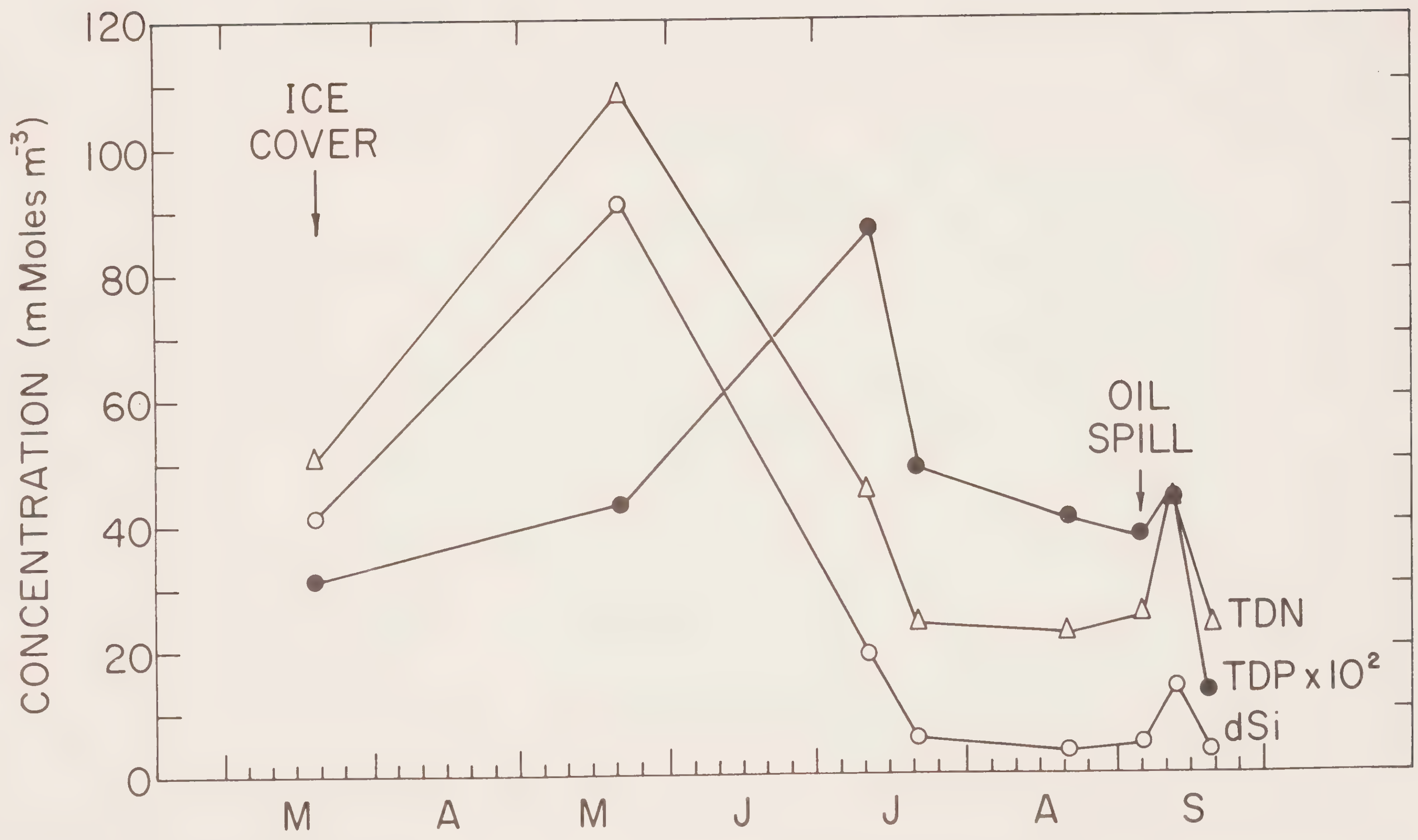


Figure 6j. Seasonal variation in concentrations of total dissolved nitrogen (TDN), phosphorus (TDP), and silica (Si). Lake 4 (1972).

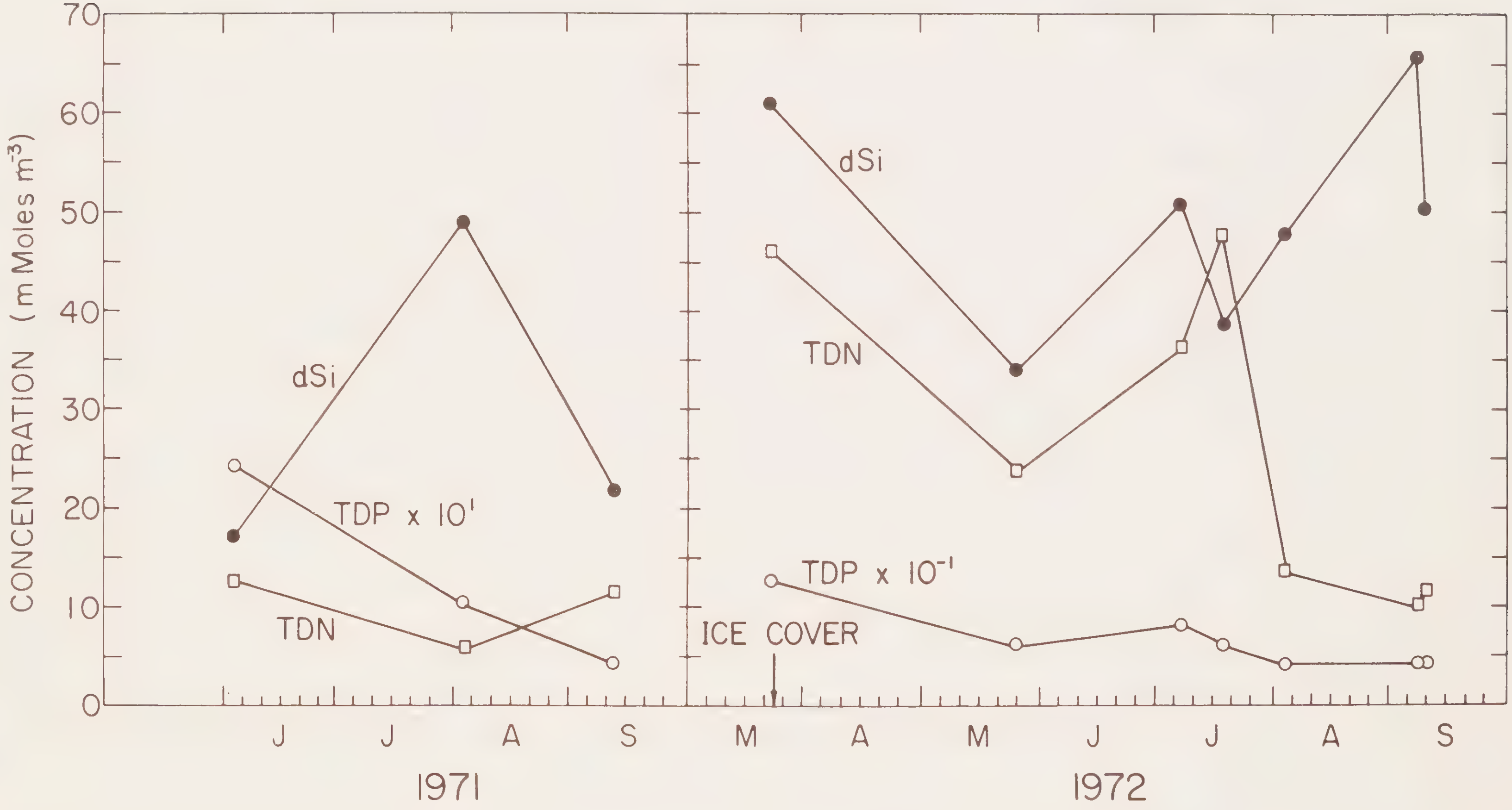


Figure 61. Seasonal variation in concentrations of total dissolved nitrogen (TDN), phosphorus (TDP), and silica (Si). Peel River at Fort McPherson (1971-72).

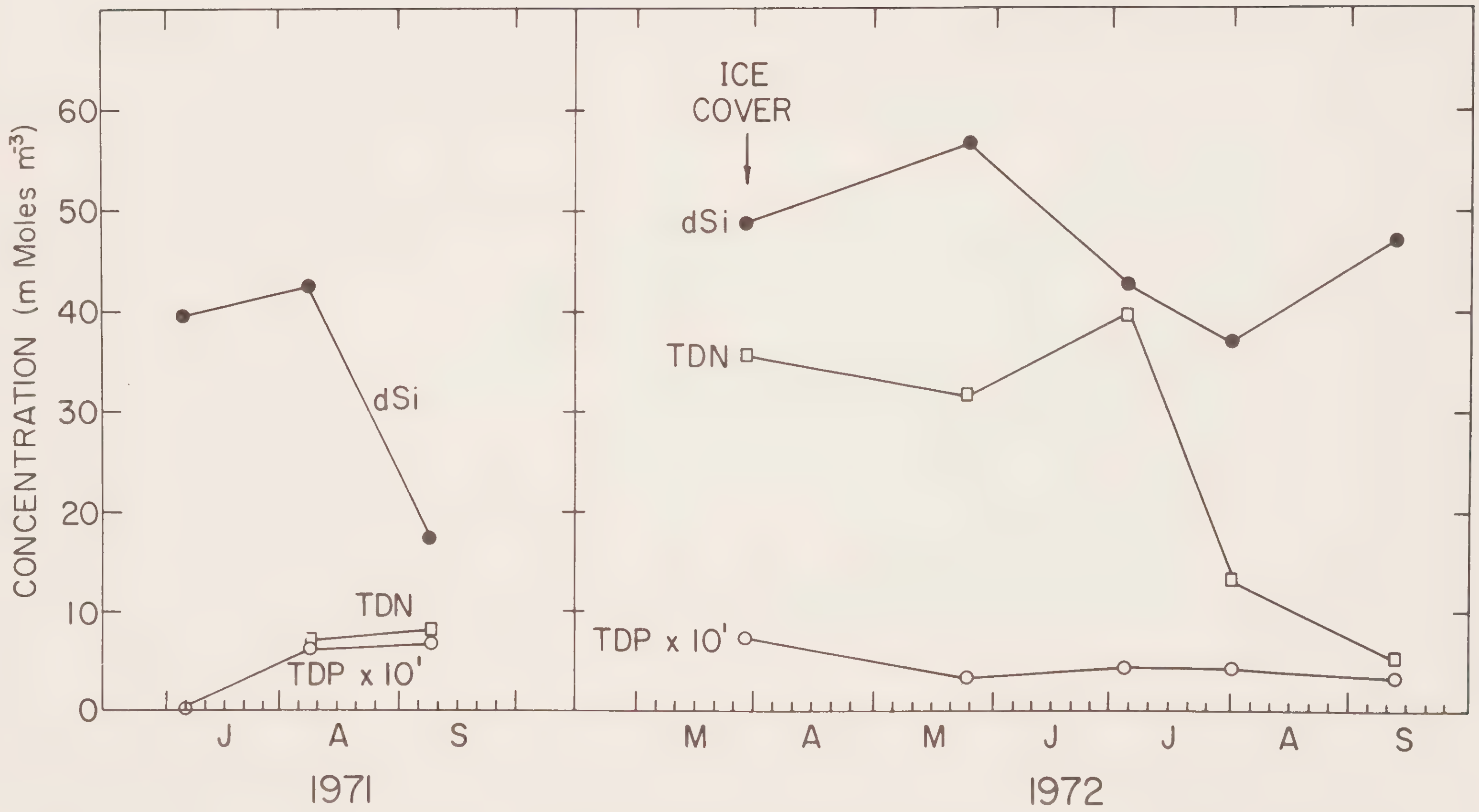


Figure 6m. Seasonal variation in concentrations of total dissolved nitrogen (TDN), phosphorus (TDP), and silica (Si). Mackenzie River at Fort Providence (1972).

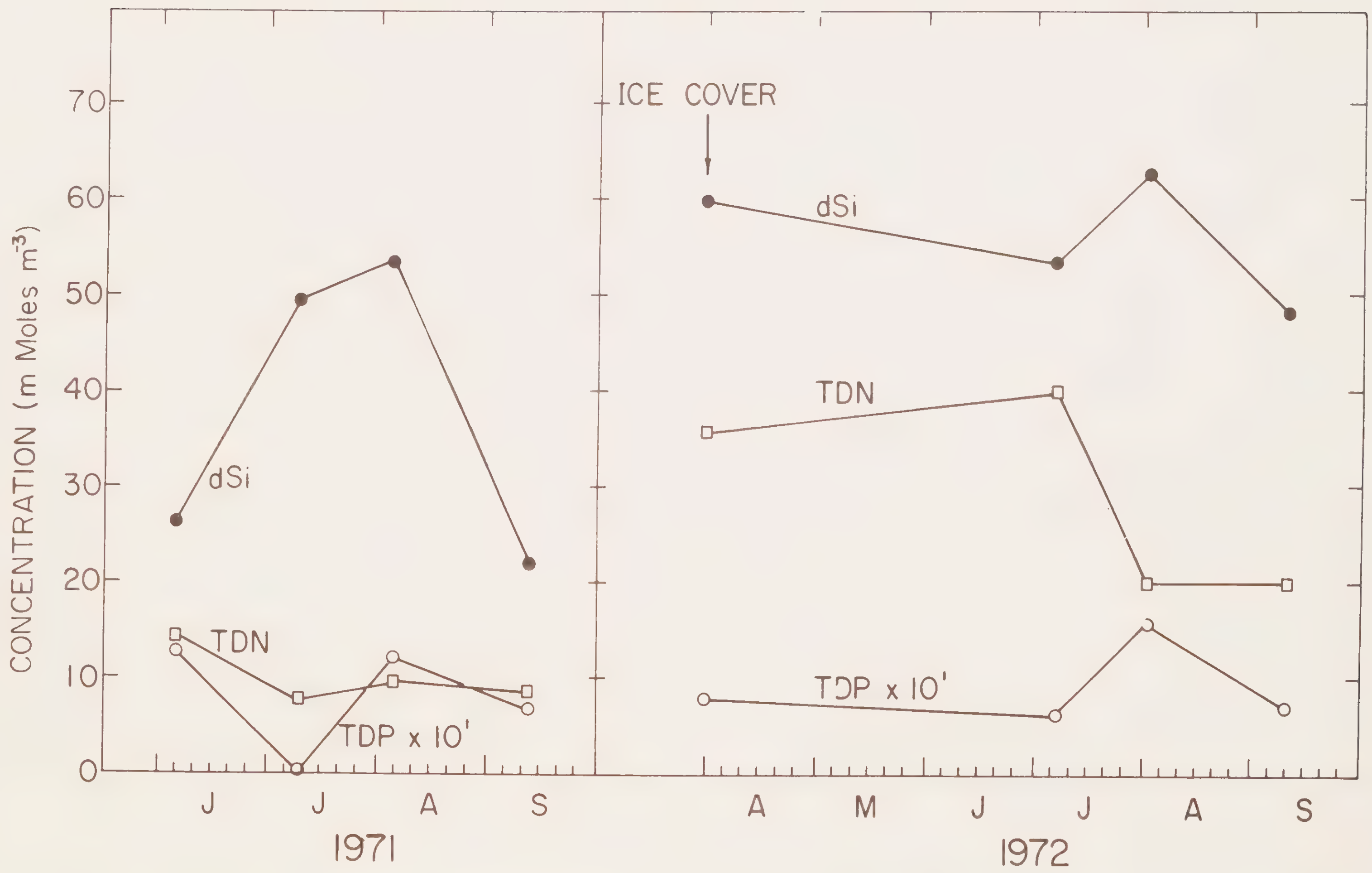


Figure 6n. Seasonal variation in concentrations of total dissolved nitrogen (TDN), phosphorus (TDP), and silica (Si). Mackenzie River at Norman Wells (1972).

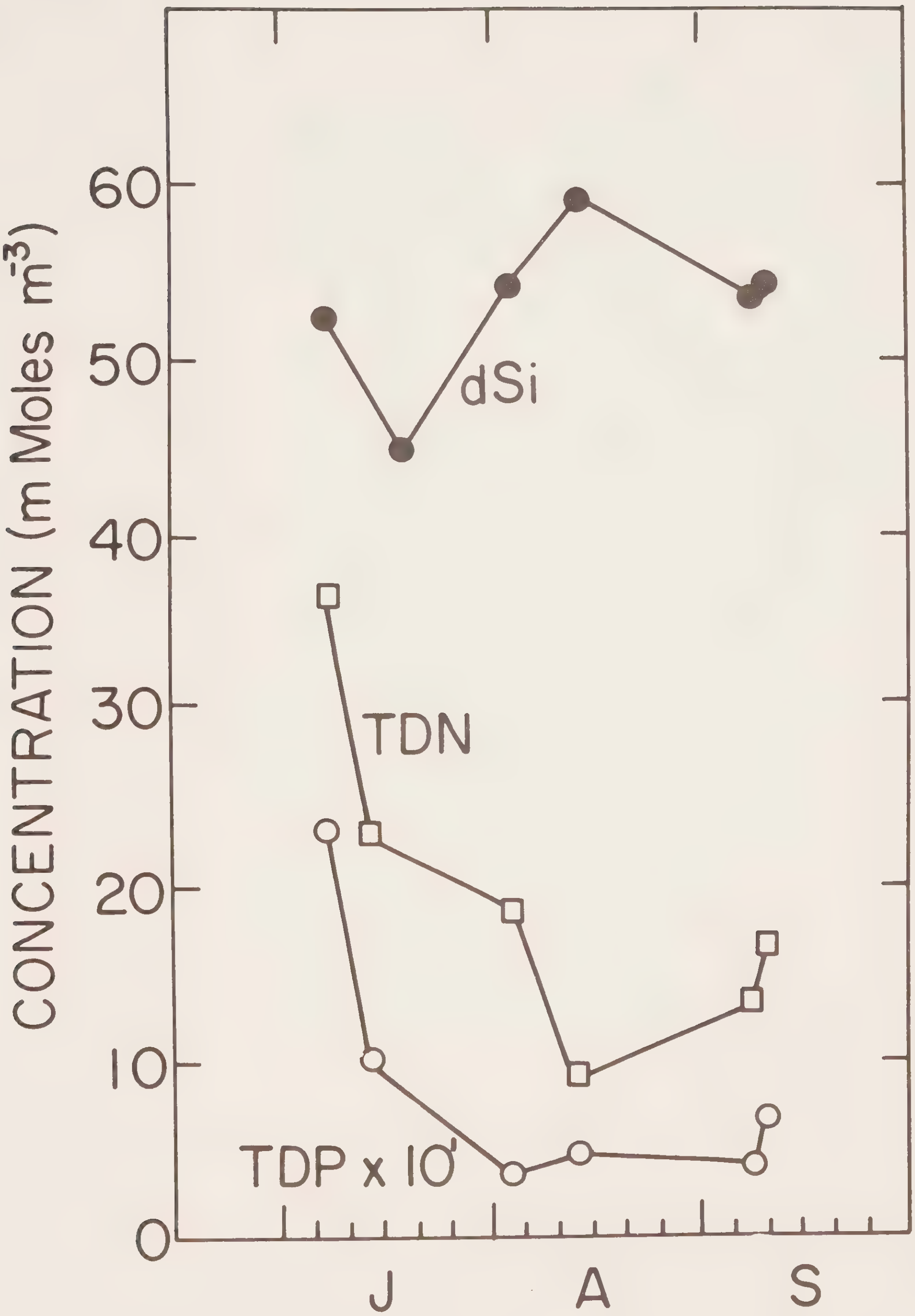


Figure 6o. Seasonal variation in concentrations of total dissolved nitrogen (TDN), phosphorus (TDP), and silica (Si). Mackenzie River at Arctic Red River (1972).

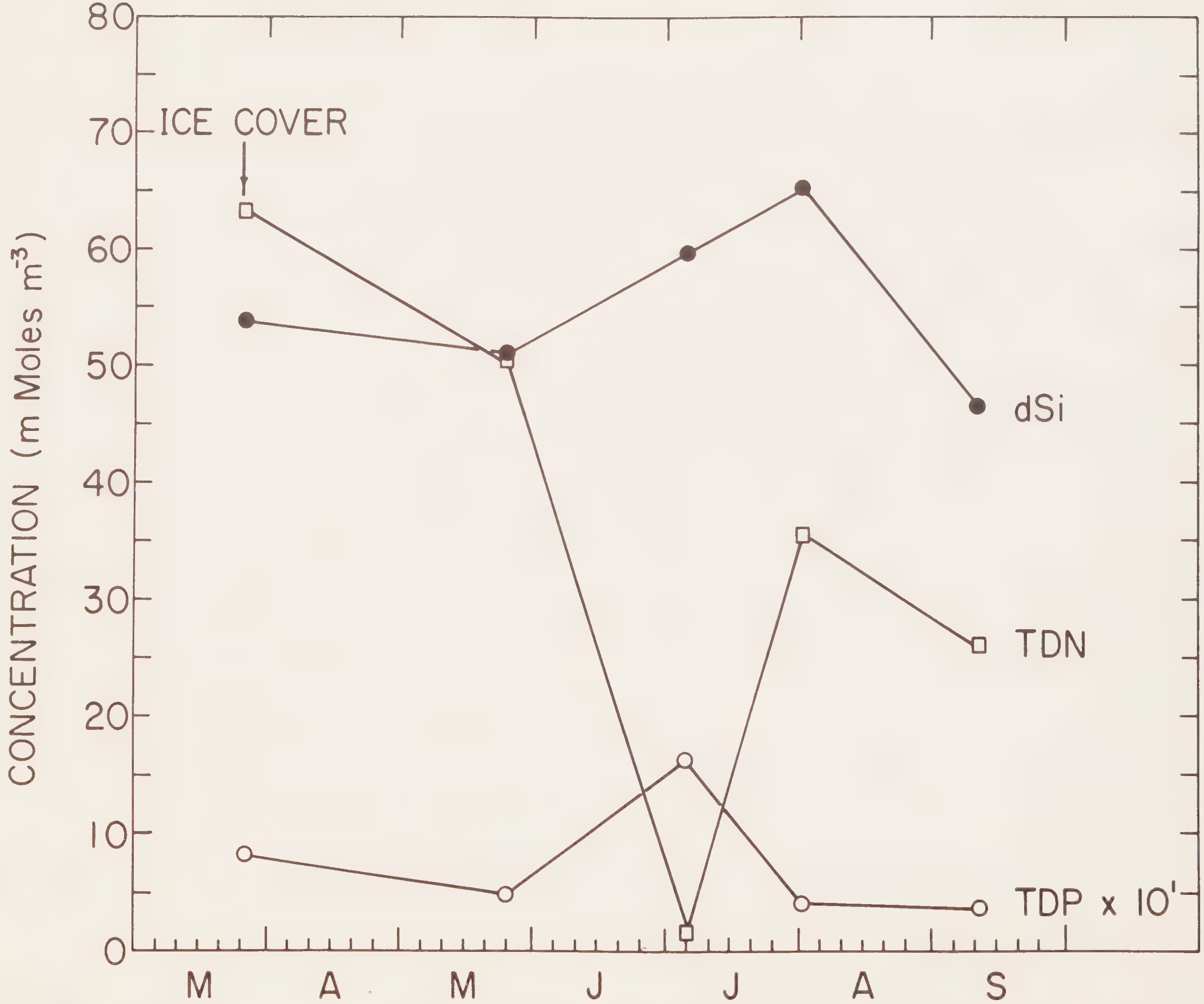


Figure 6p. Seasonal variation in concentrations of total dissolved nitrogen (TDN), phosphorus (TDP), and silica (Si). Willowlake River (1972).

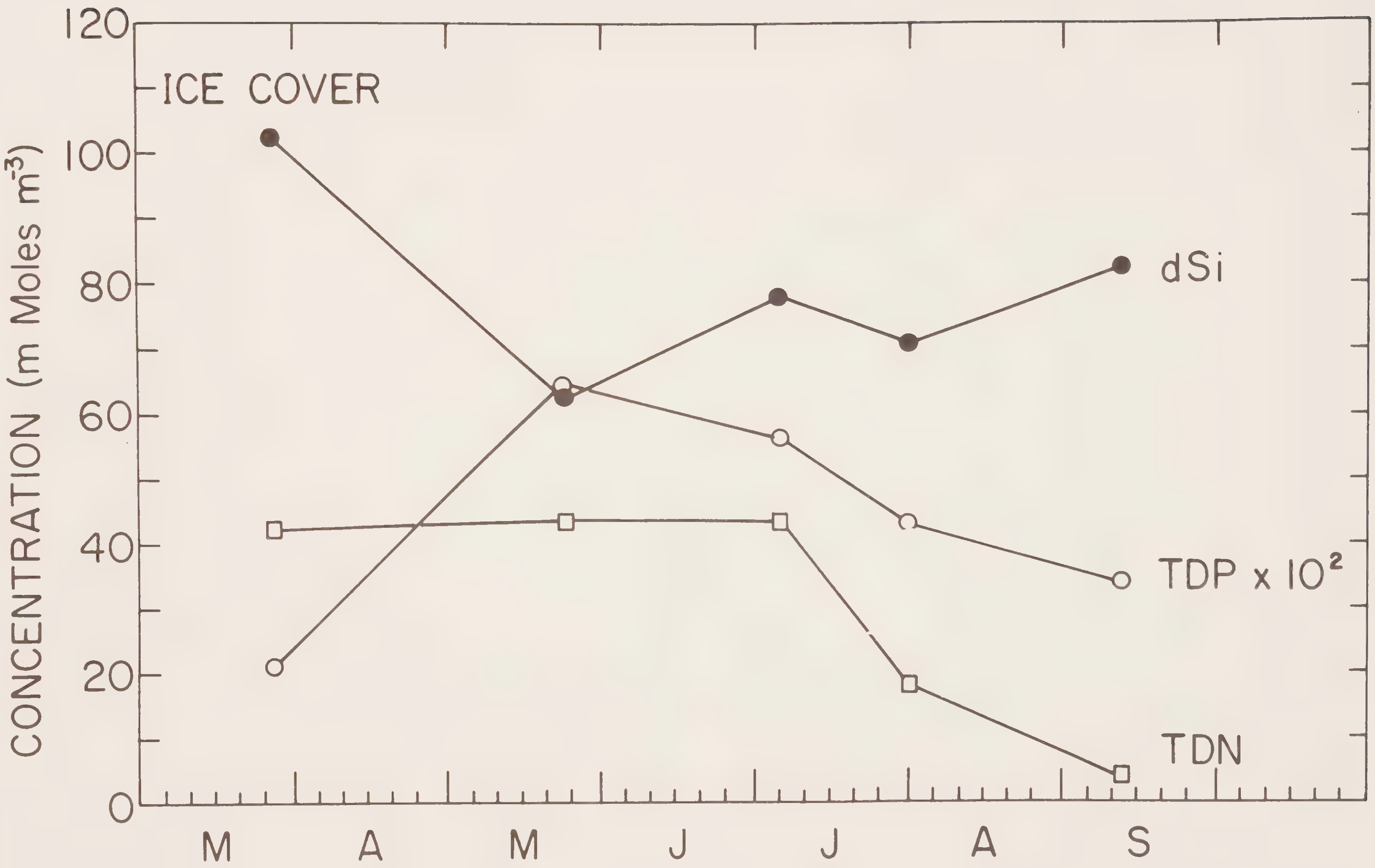


Figure 6q. Seasonal variation in concentrations of total dissolved nitrogen (TDN), phosphorus (TDP), and silica (Si). Liard River at Fort Liard (1972).

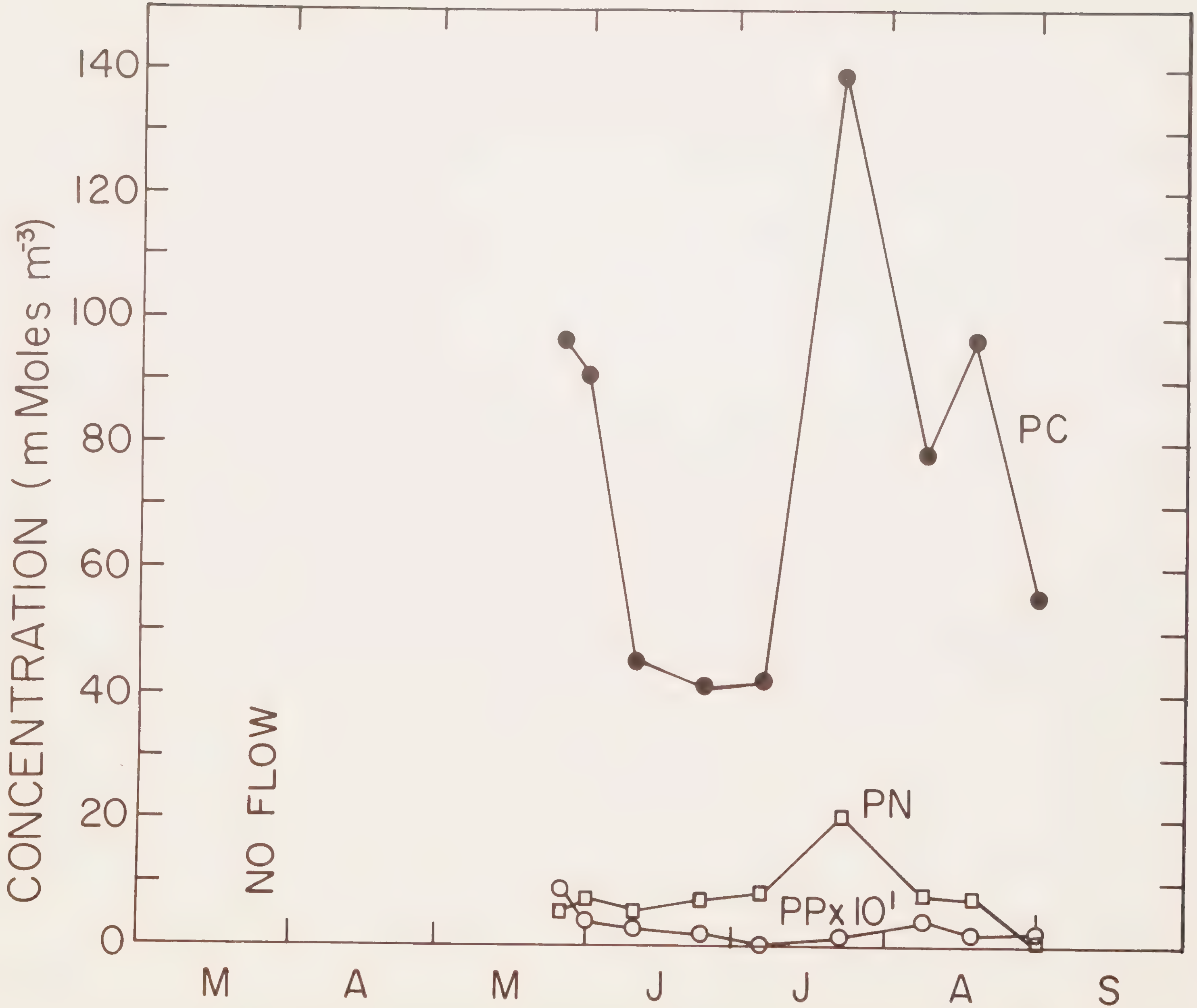


Figure 7a. Seasonal variation in concentrations of total particulate carbon (PC), nitrogen (PN), and phosphorus (PP). Harris River at Mackenzie River (1972).

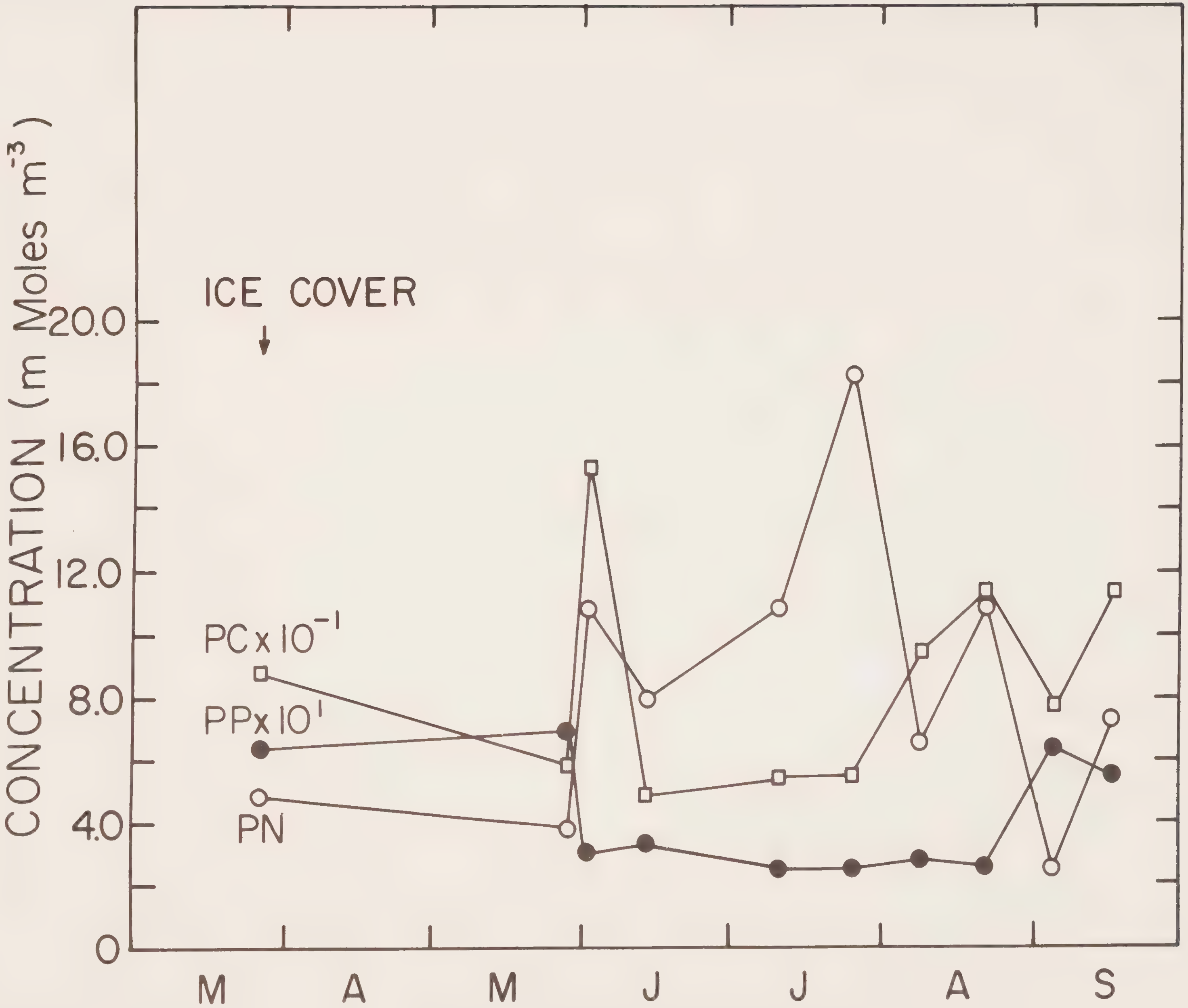


Figure 7b. Seasonal variation in concentrations of total particulate carbon (PC), nitrogen (PN), and phosphorus (PP). Jean Marie Creek at Mackenzie River (1972).

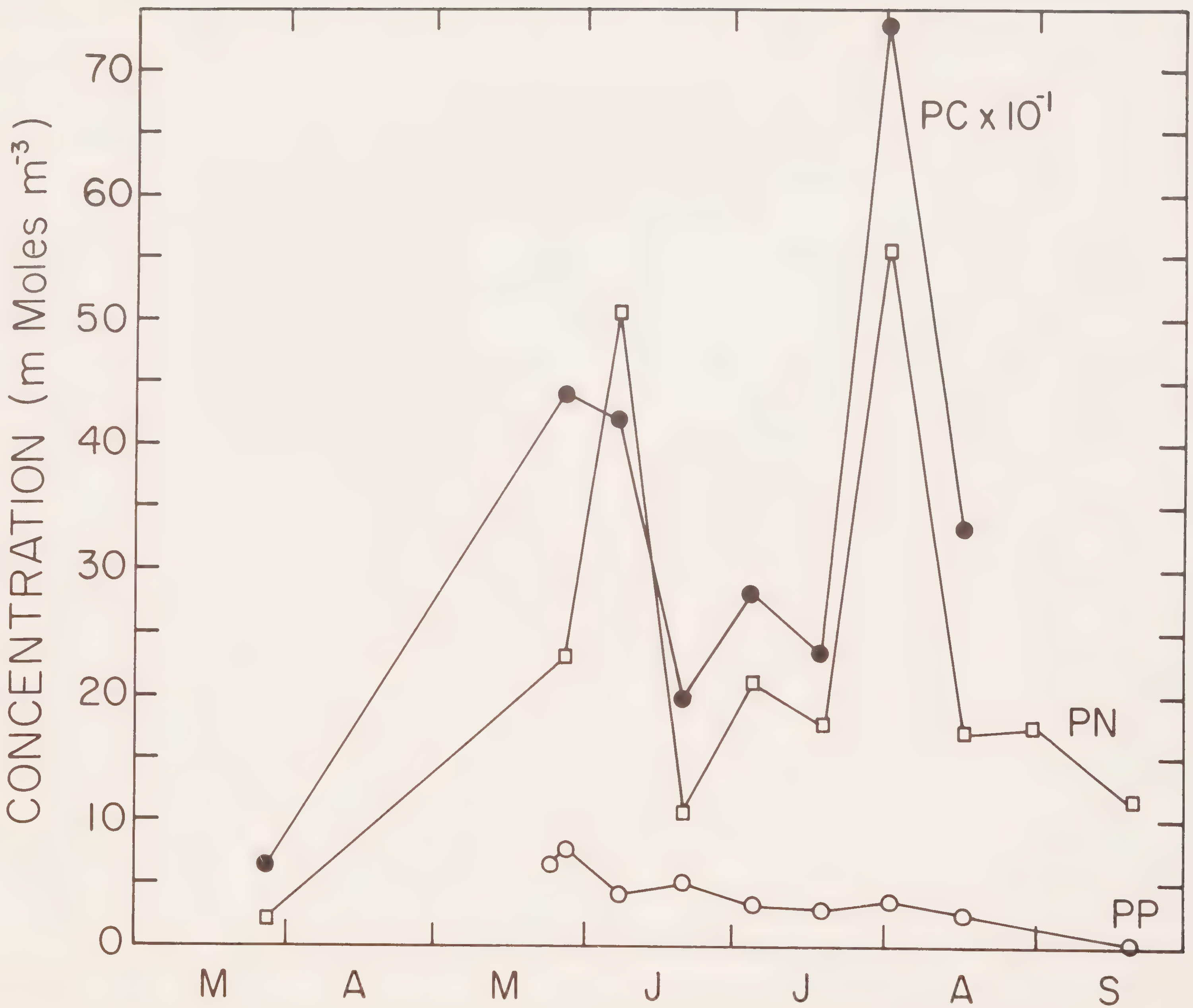


Figure 7c. Seasonal variation in concentrations of total particulate carbon (PC), nitrogen (PN), and phosphorus (PP). Liard River at Fort Simpson (1972).

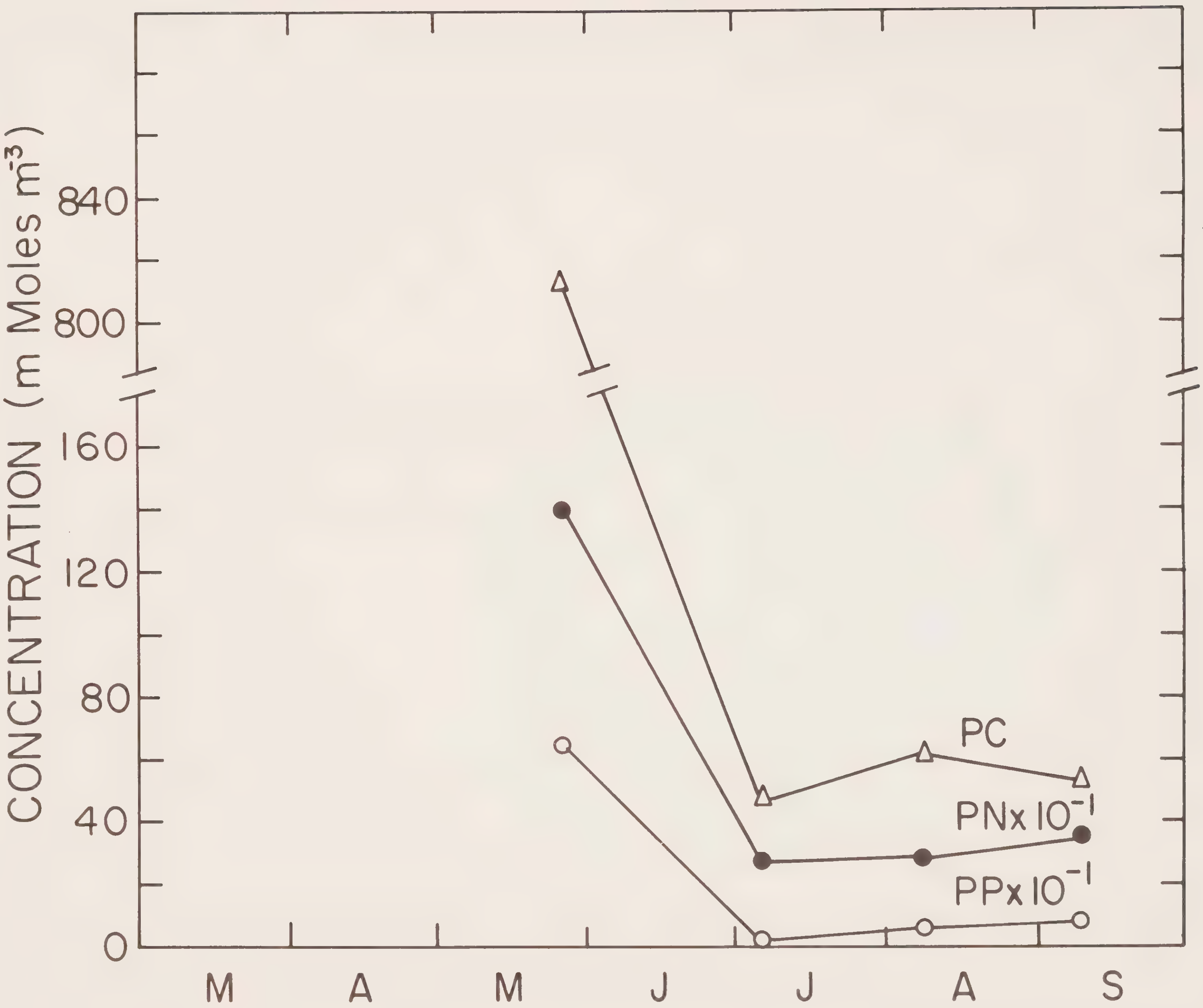


Figure 7d. Seasonal variation in concentrations of total particulate carbon (PC), nitrogen (PN), and phosphorus (PP). Mackenzie River above Fort Simpson (1971).

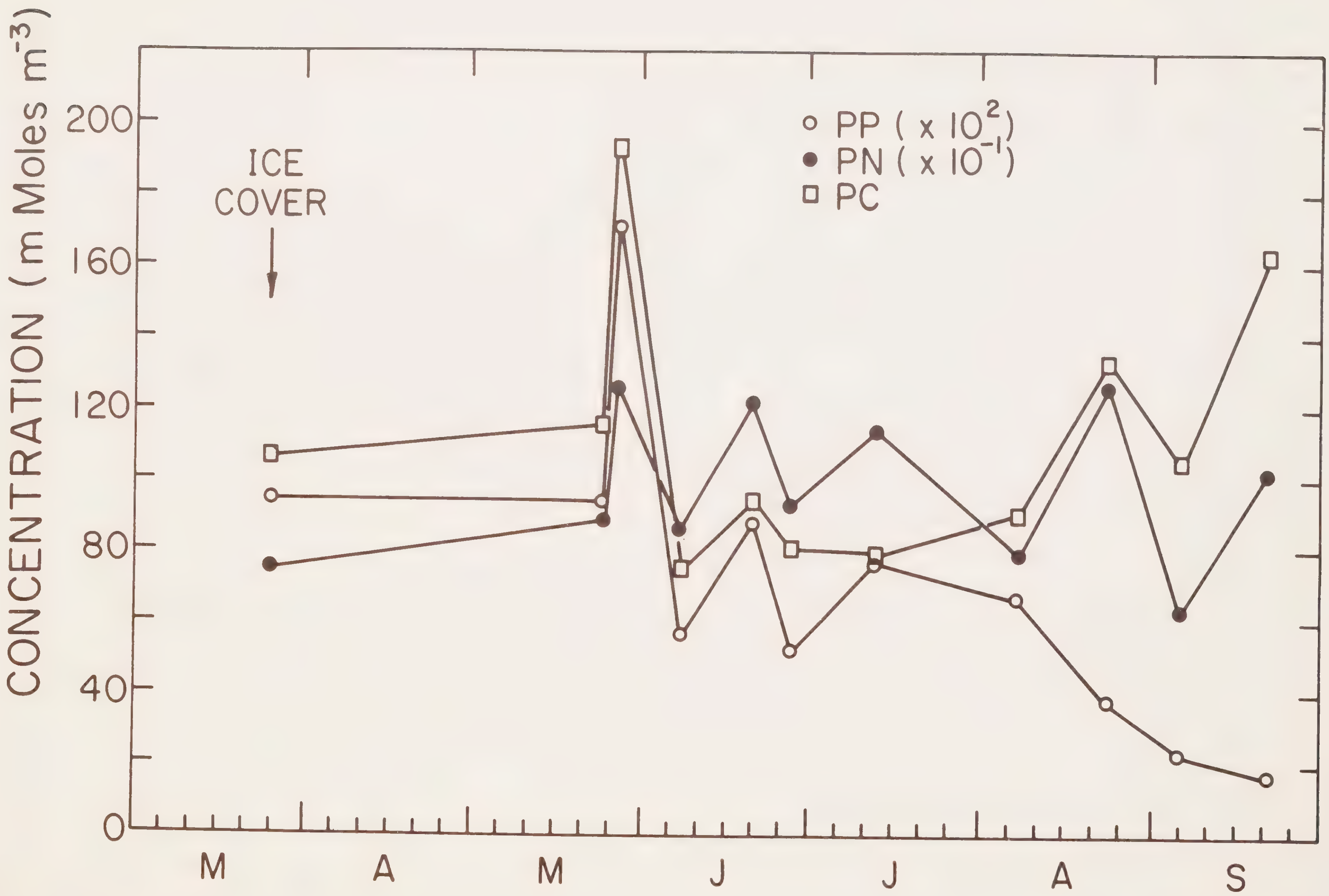


Figure 7e. Seasonal variation in concentrations of total particulate carbon (PC), nitrogen (PN), and phosphorus (PP). Mackenzie River above Fort Simpson (1972).

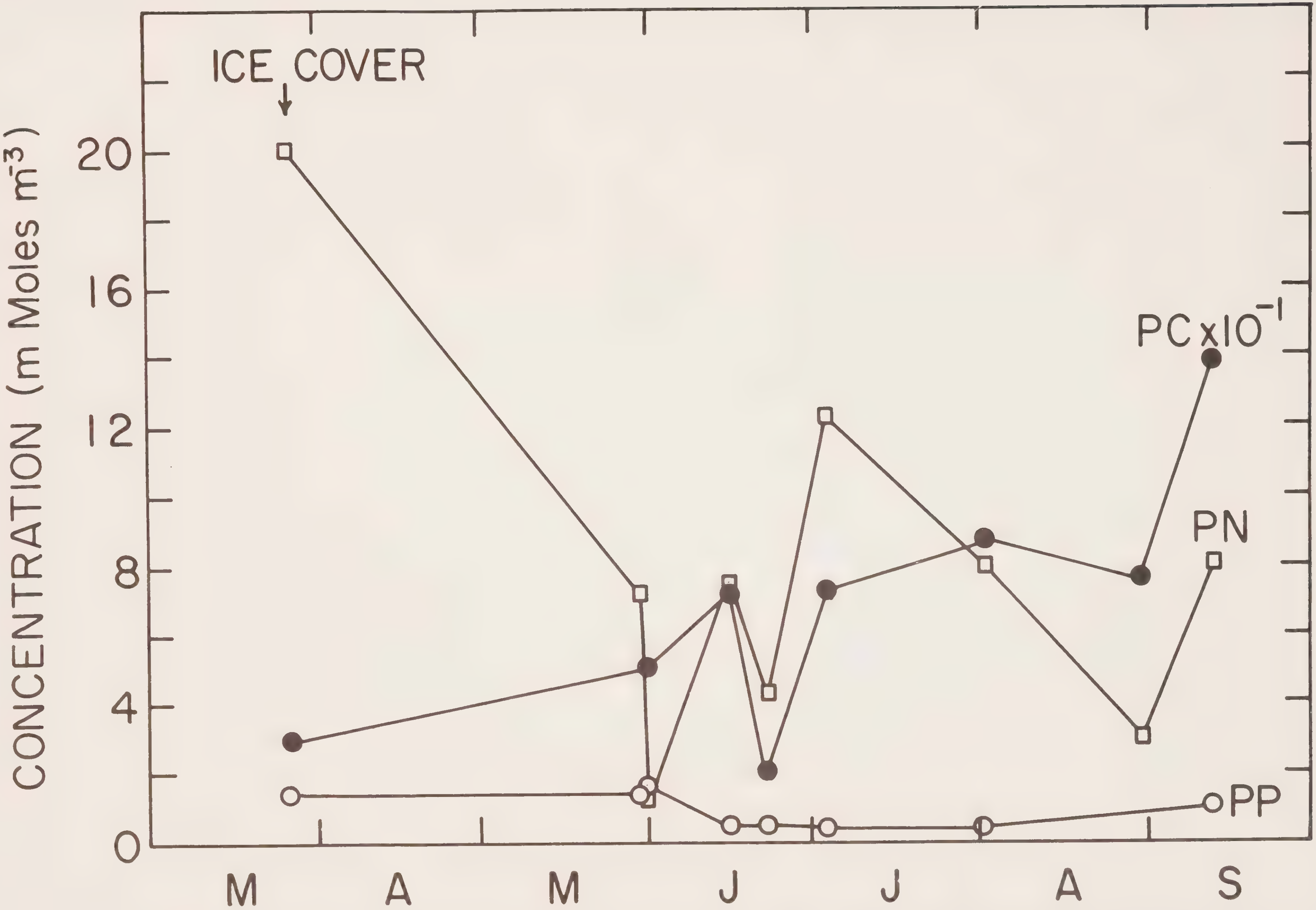


Figure 7f. Seasonal variation in concentrations of total particulate carbon (PC), nitrogen (PN), and phosphorus (PP). Martin River at Mackenzie River (1972).

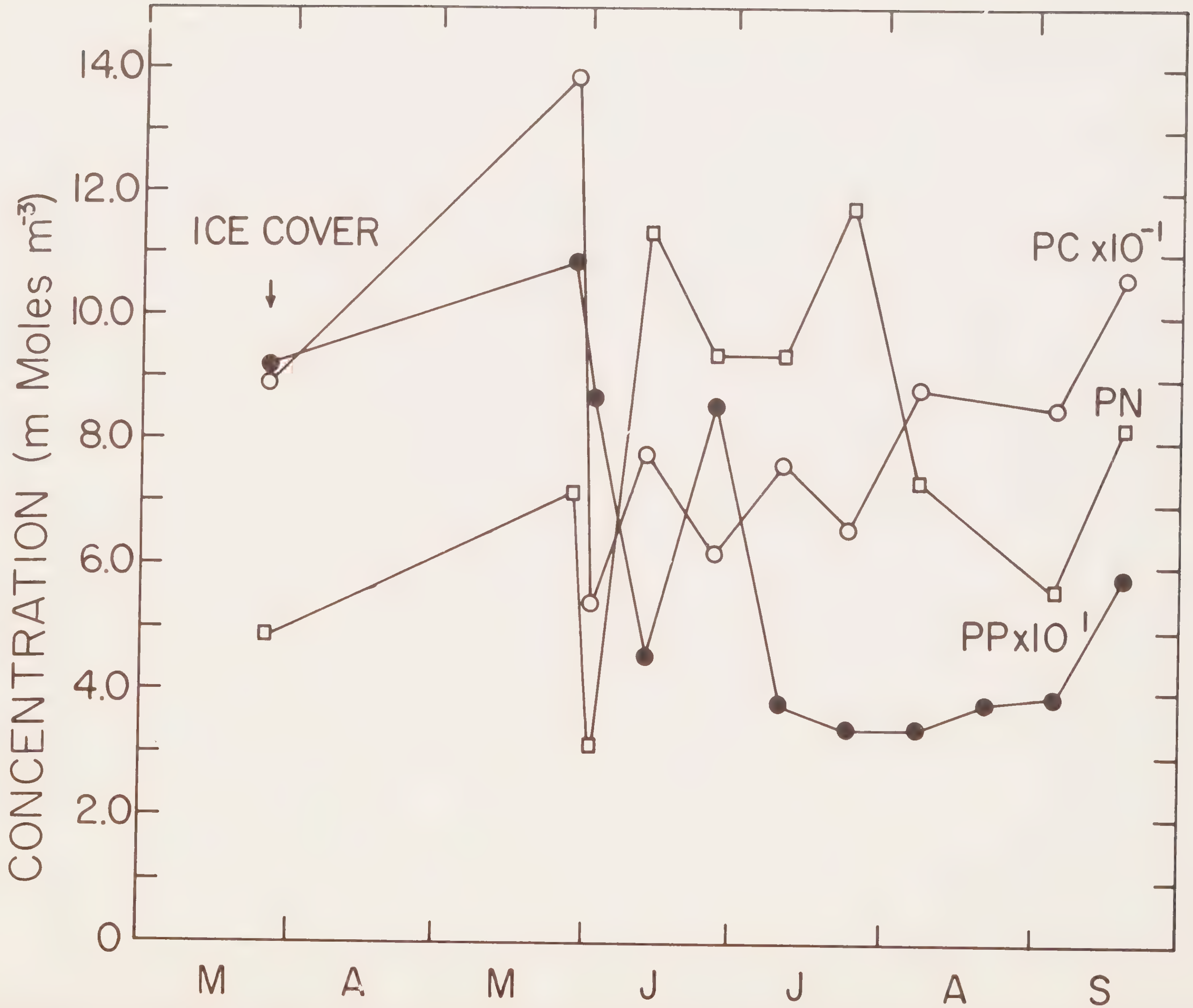


Figure 7g. Seasonal variation in concentrations of total particulate carbon (PC), nitrogen (PN), and phosphorus (PP). Rabbitskin River at Mackenzie River (1972).

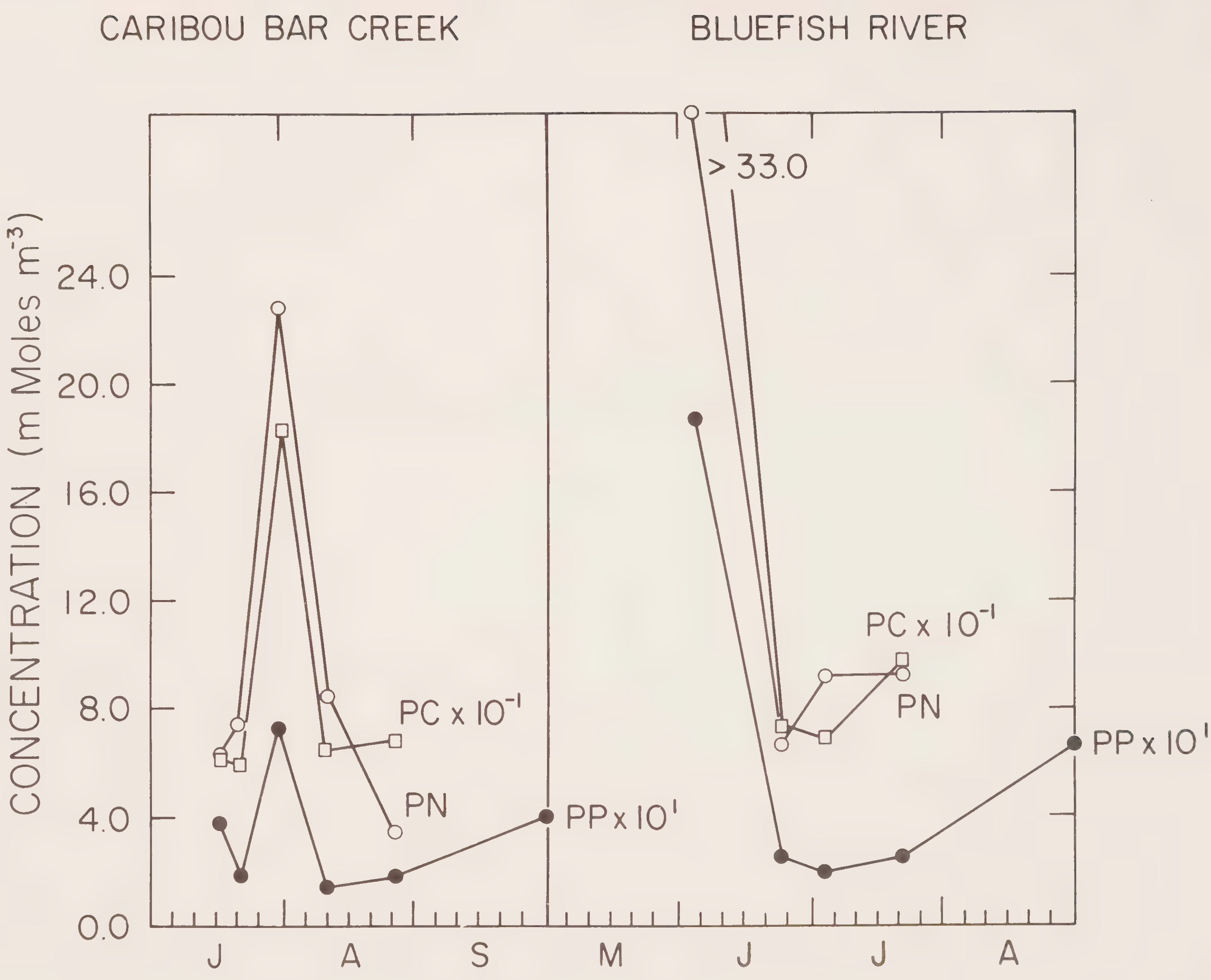


Figure 7h. Seasonal variation in concentrations of total particulate carbon (PC), nitrogen (PN), and phosphorus (PP). Bluefish River and Caribou Bar Creek (1972).

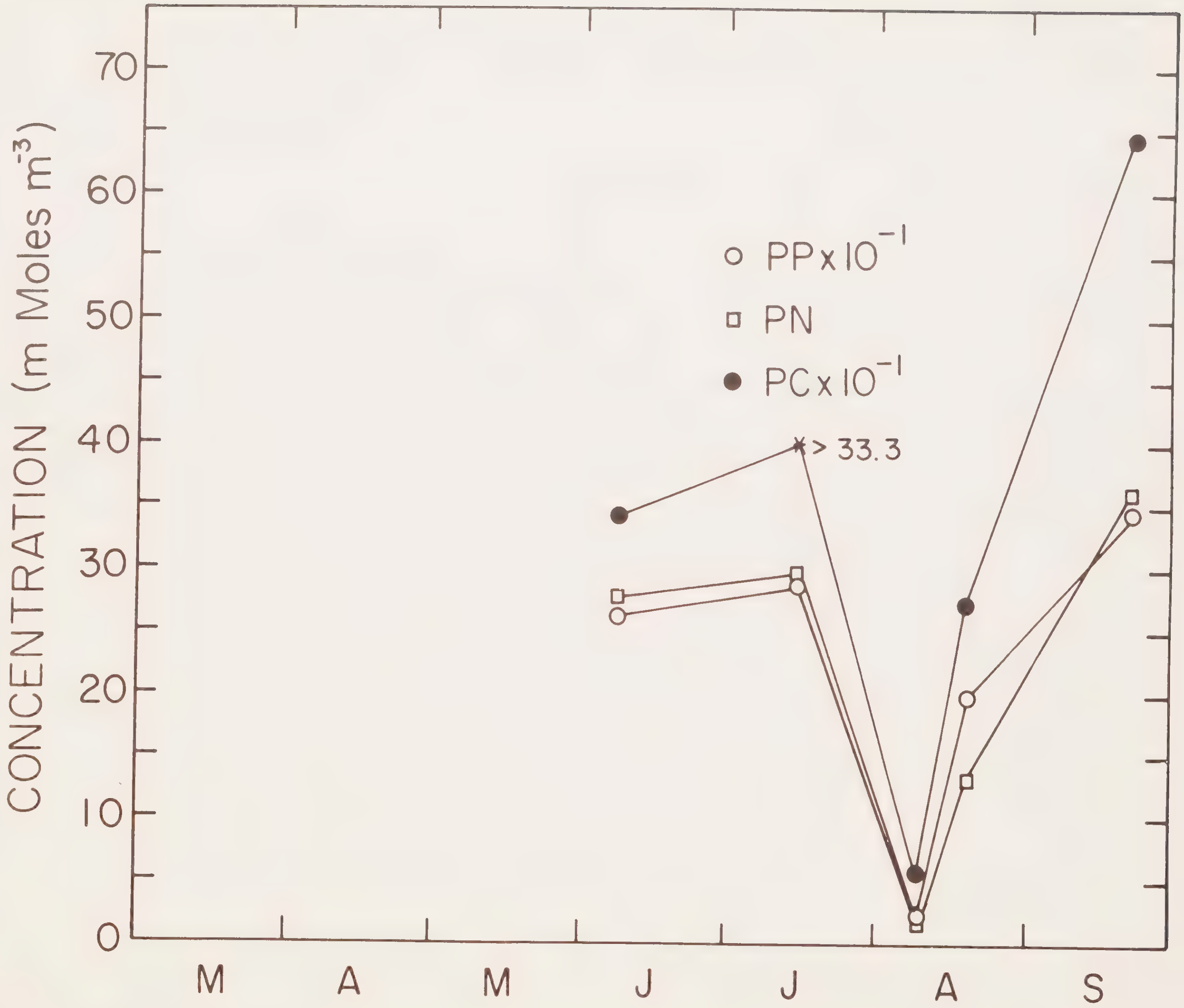


Figure 7i. Seasonal variation in concentrations of total particulate carbon (PC), nitrogen (PN), and phosphorus (PP). Kugmallit Bay - KU4 (1972).

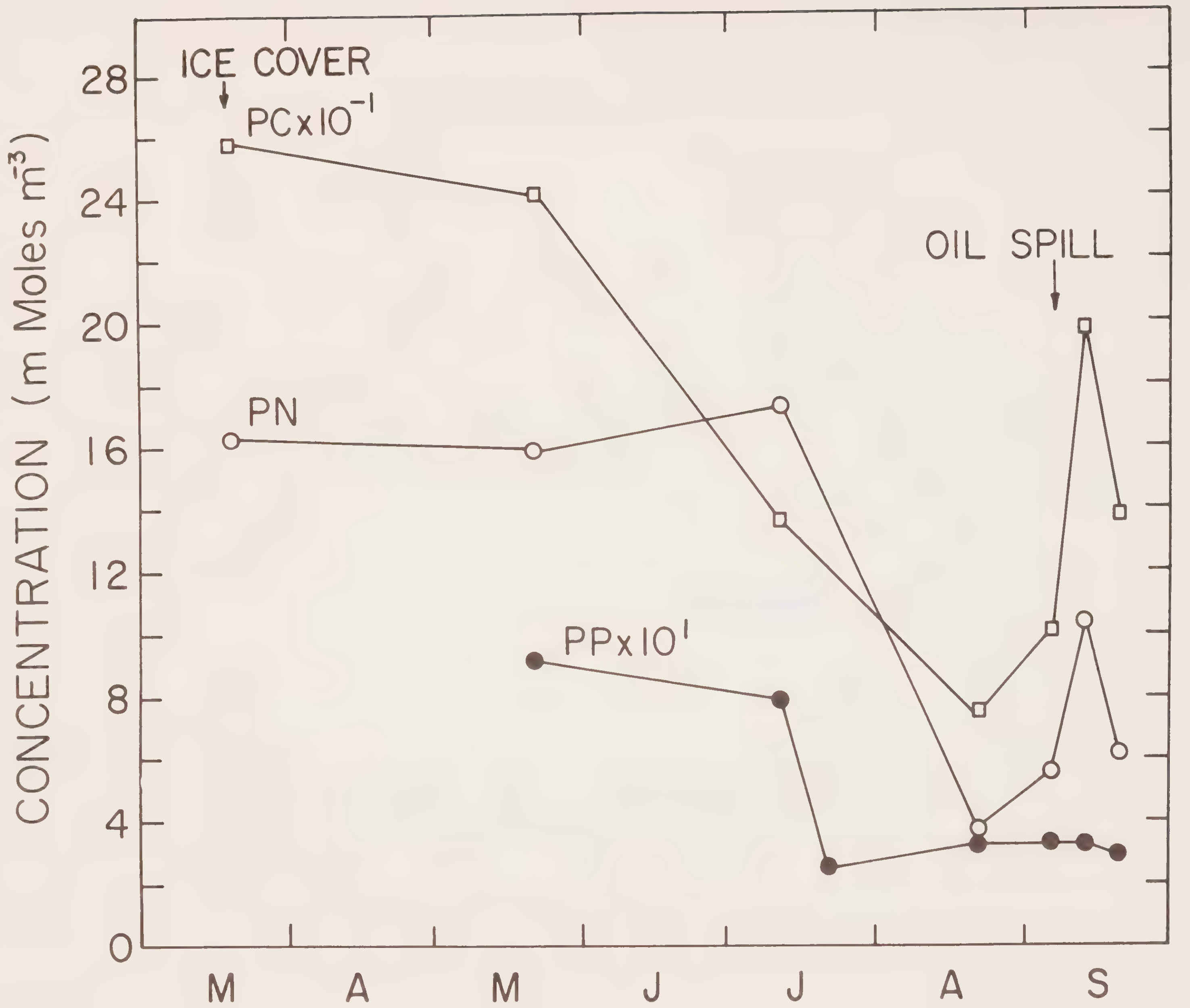


Figure 7j. Seasonal variation in concentrations of total particulate carbon (PC), nitrogen (PN), and phosphorus (PP). Lake 4 (1972).

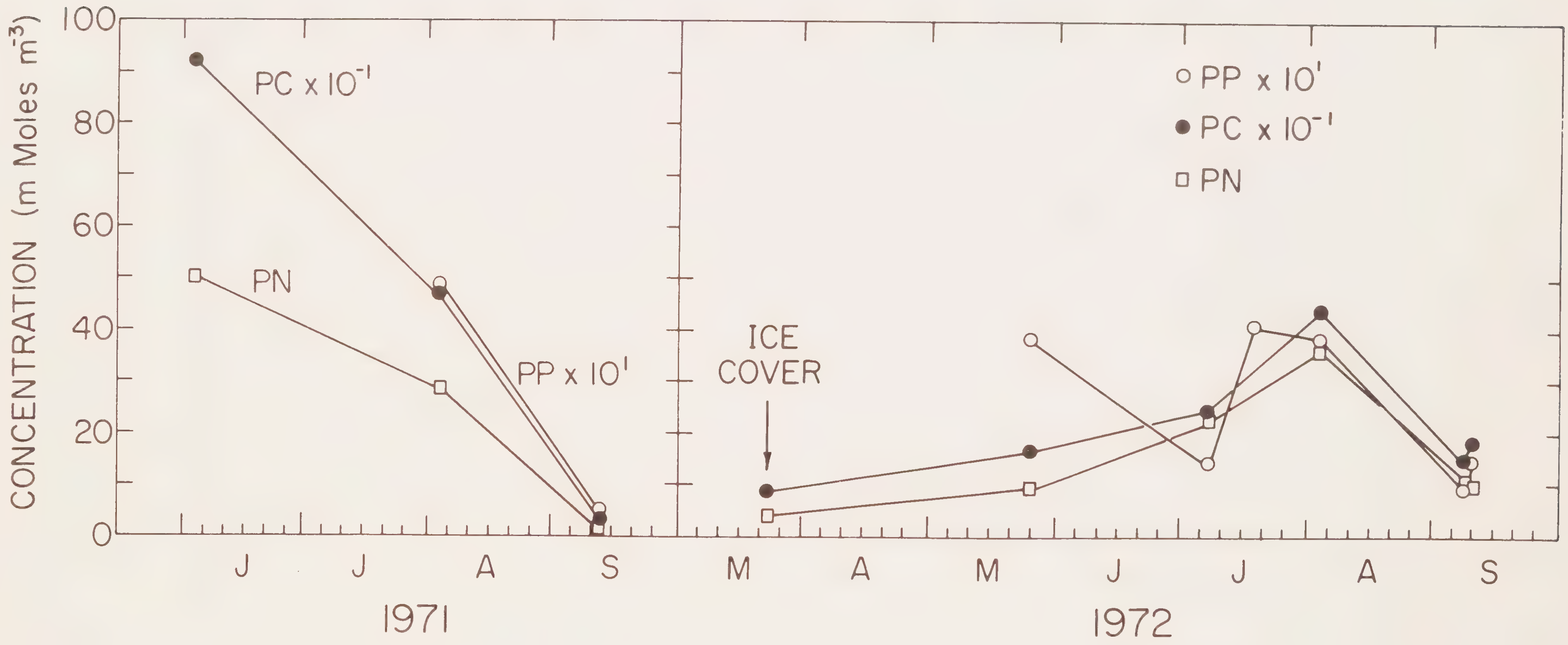


Figure 71. Seasonal variation in concentrations of total particulate carbon (PC), nitrogen (PN), and phosphorus (PP). Peel River at Fort McPherson (1971-72).

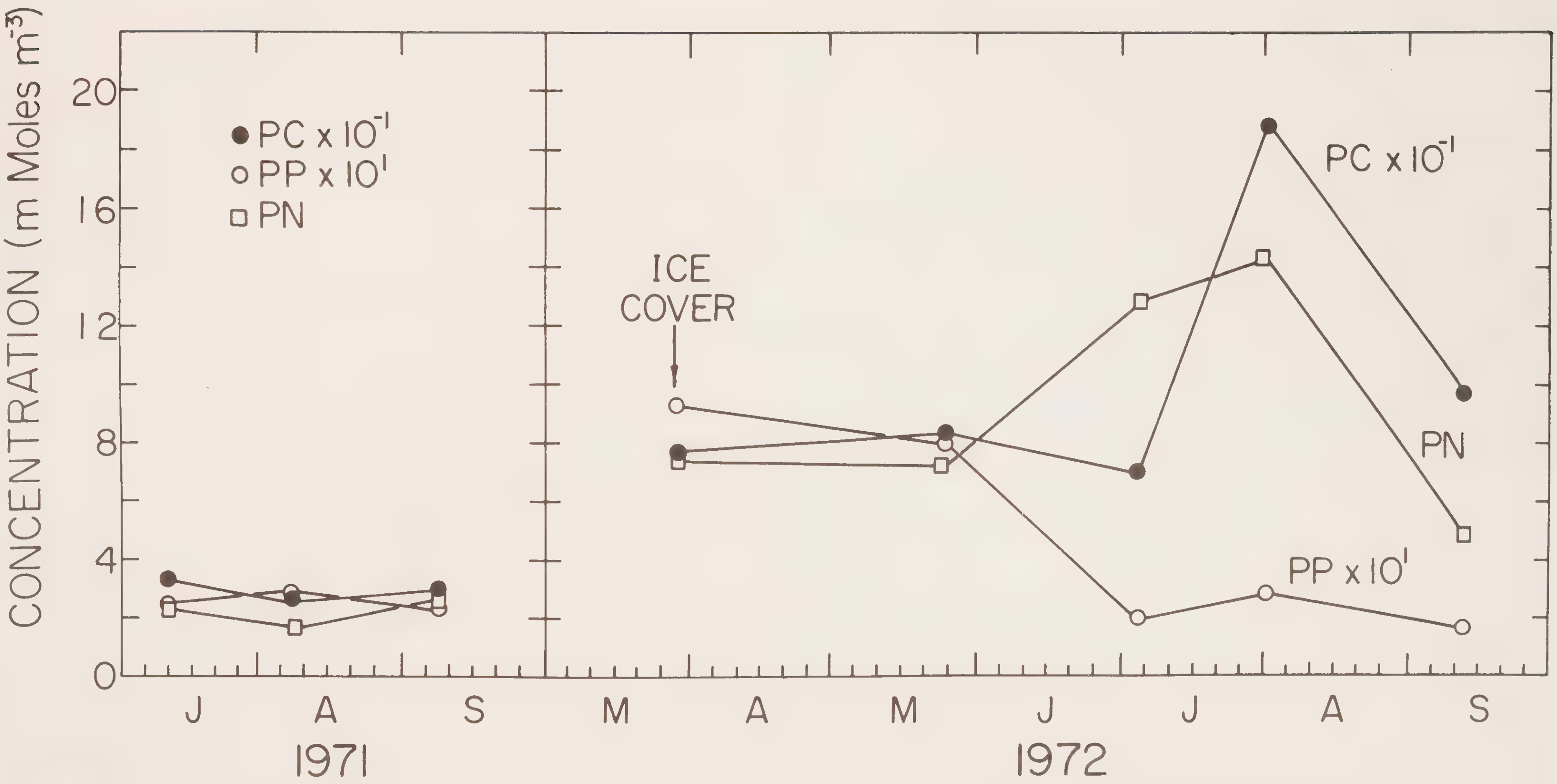


Figure 7m. Seasonal variation in concentrations of total particulate carbon (PC), nitrogen (PN), and phosphorus (PP). Mackenzie River at Fort Providence (1972).

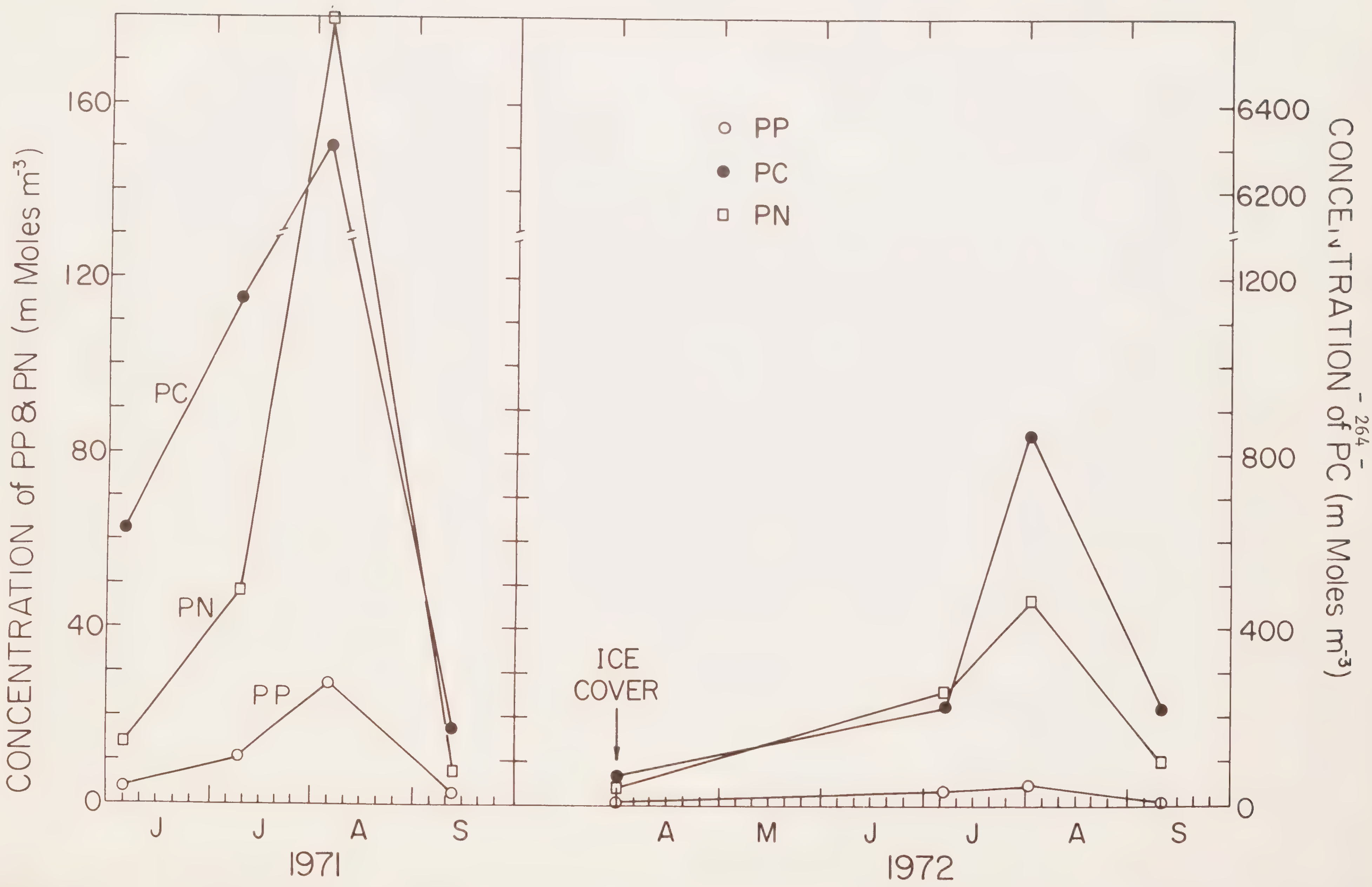


Figure 7n. Seasonal variation in concentrations of total particulate carbon (PC), nitrogen (PN), and phosphorus (PP). Mackenzie River at Norman Wells (1972).

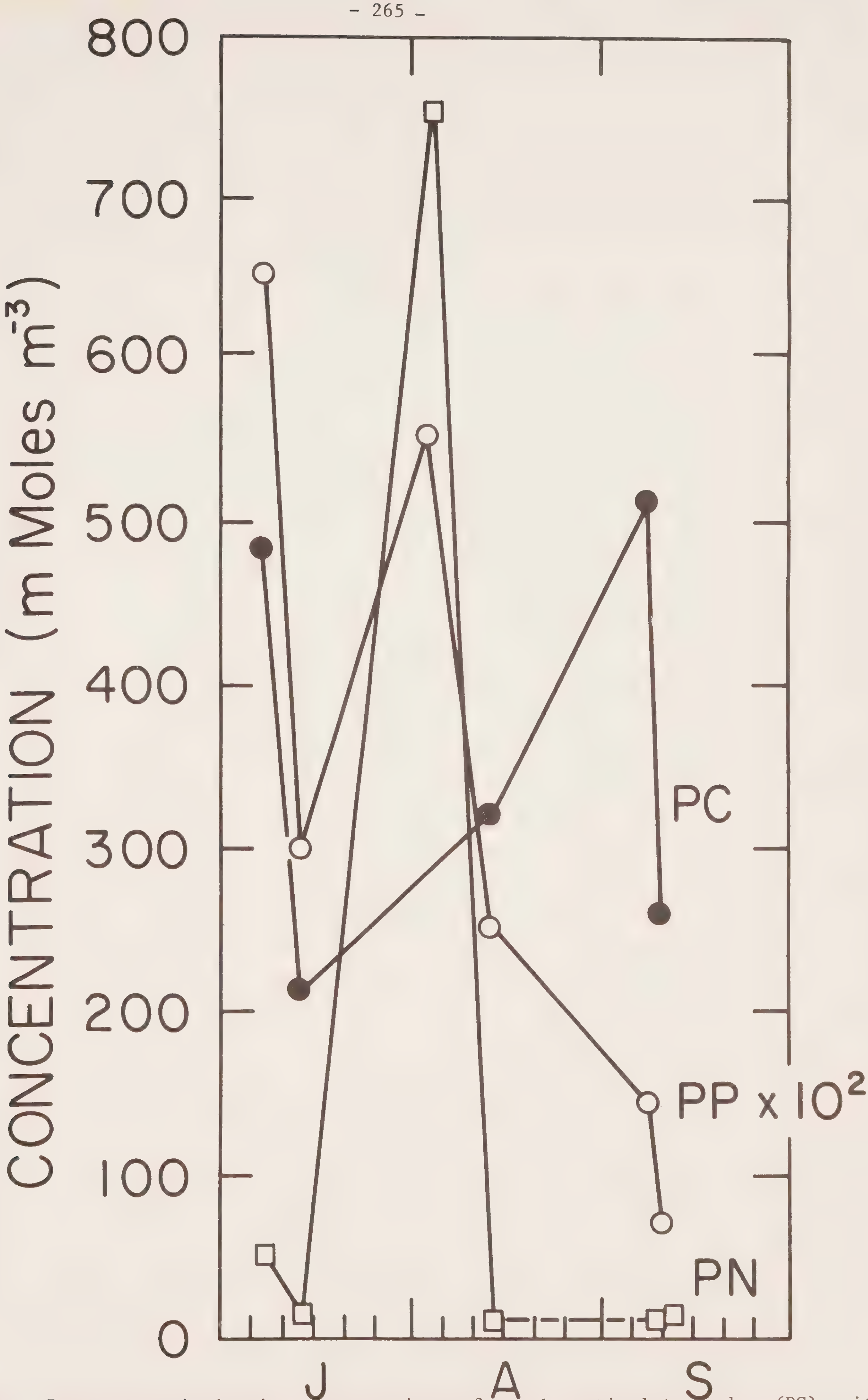


Figure 7o. Seasonal variation in concentrations of total particulate carbon (PC), nitrogen (PN), and phosphorus (PP). Mackenzie River at Arctic Red River (1972).

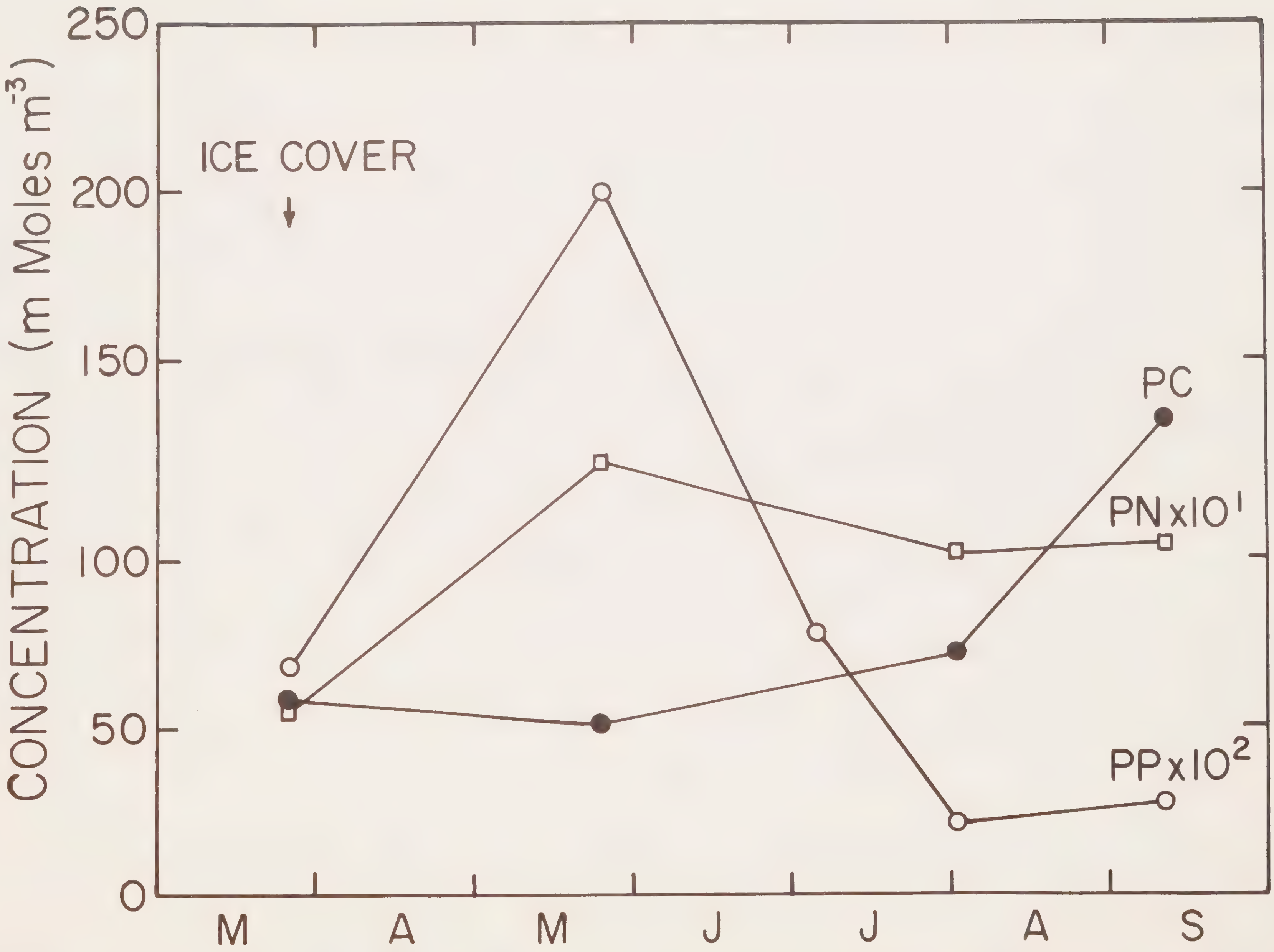


Figure 7p. Seasonal variation in concentrations of total particulate carbon (PC), nitrogen (PN), and phosphorus (PP). Willowlake River (1972).

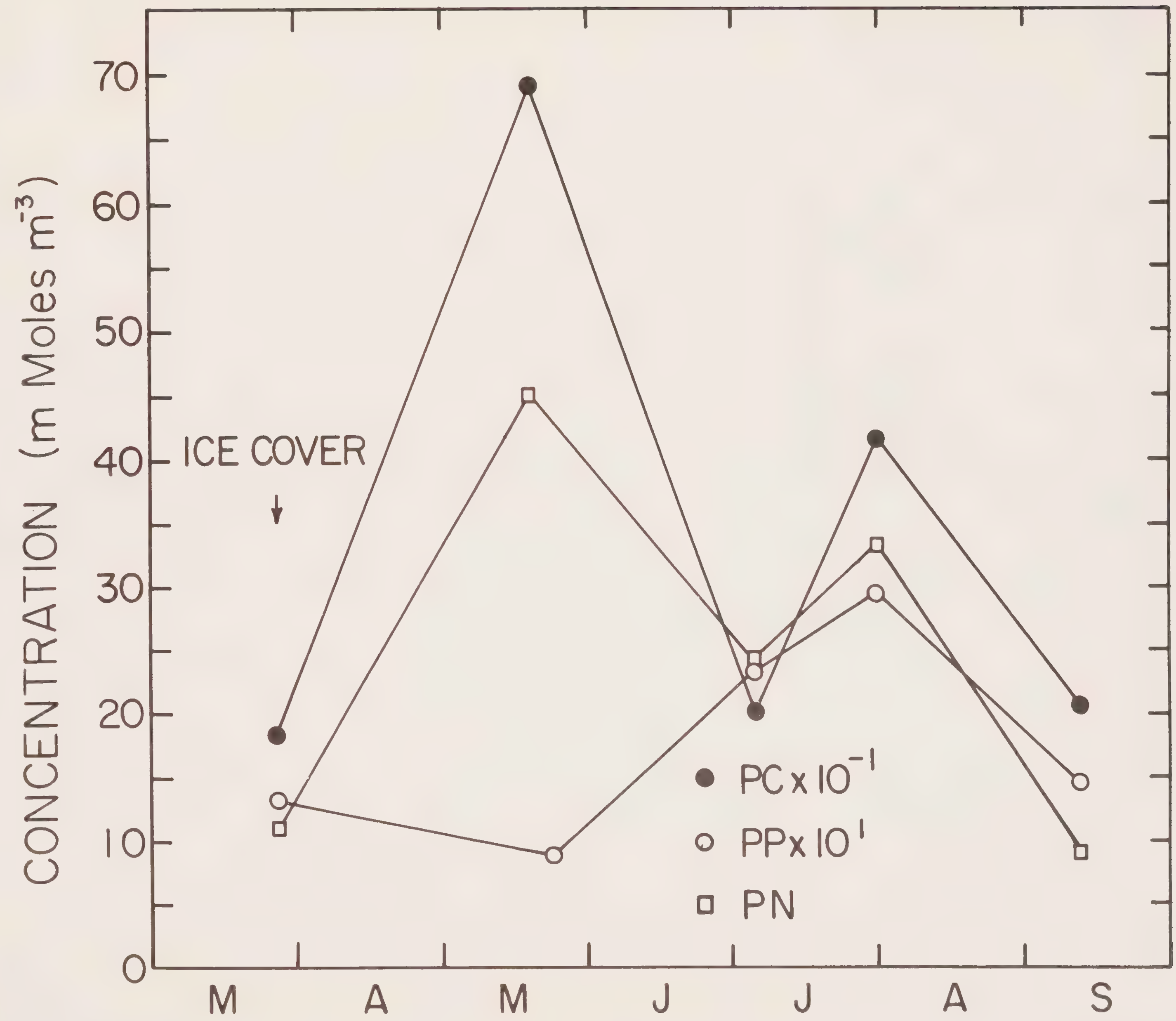


Figure 7q. Seasonal variation in concentrations of total particulate carbon (PC), nitrogen (PN), and phosphorus (PP). Liard River at Fort Liard (1972).

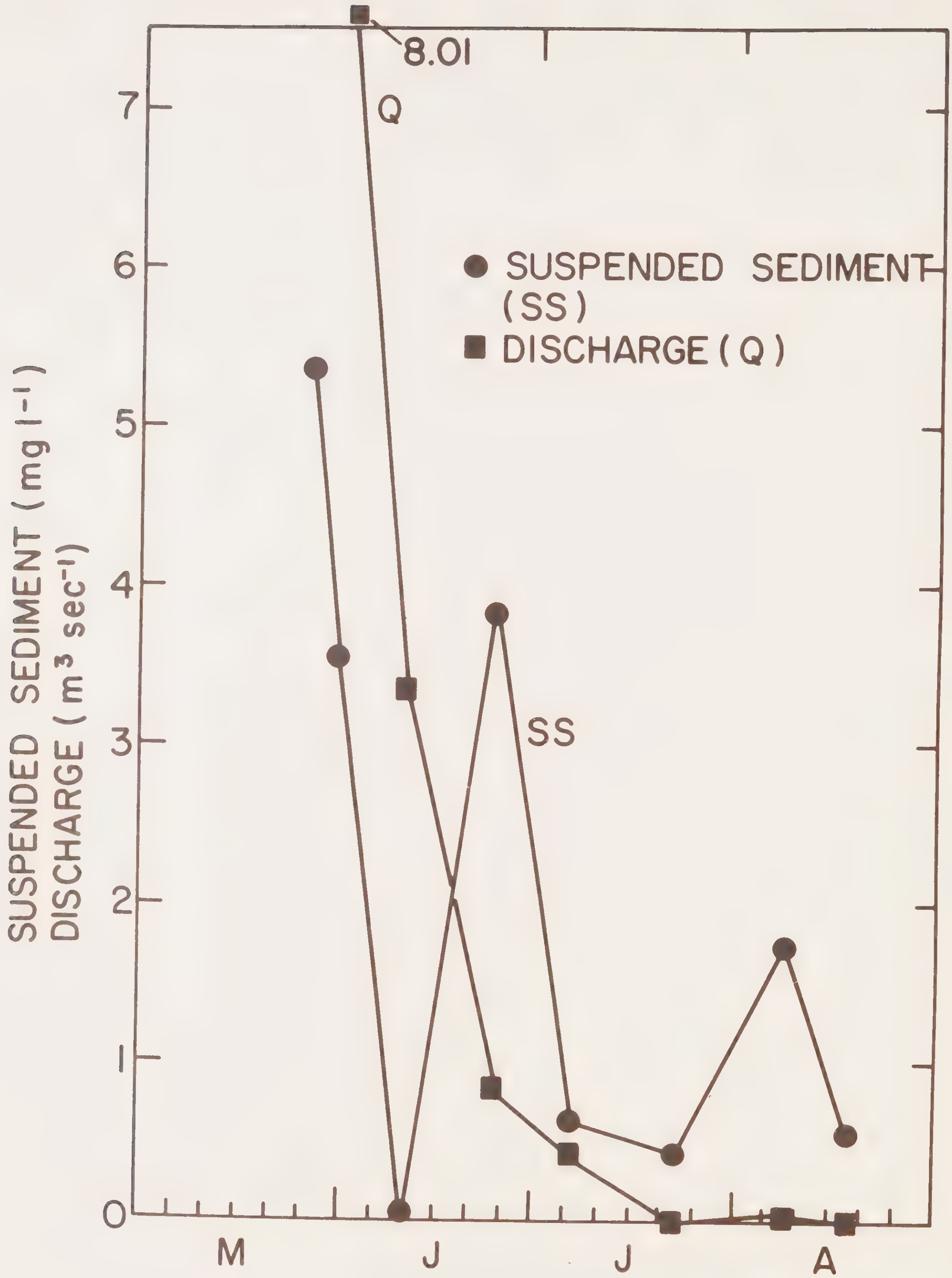


Figure 8a. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Harris River at Mackenzie River (1972).

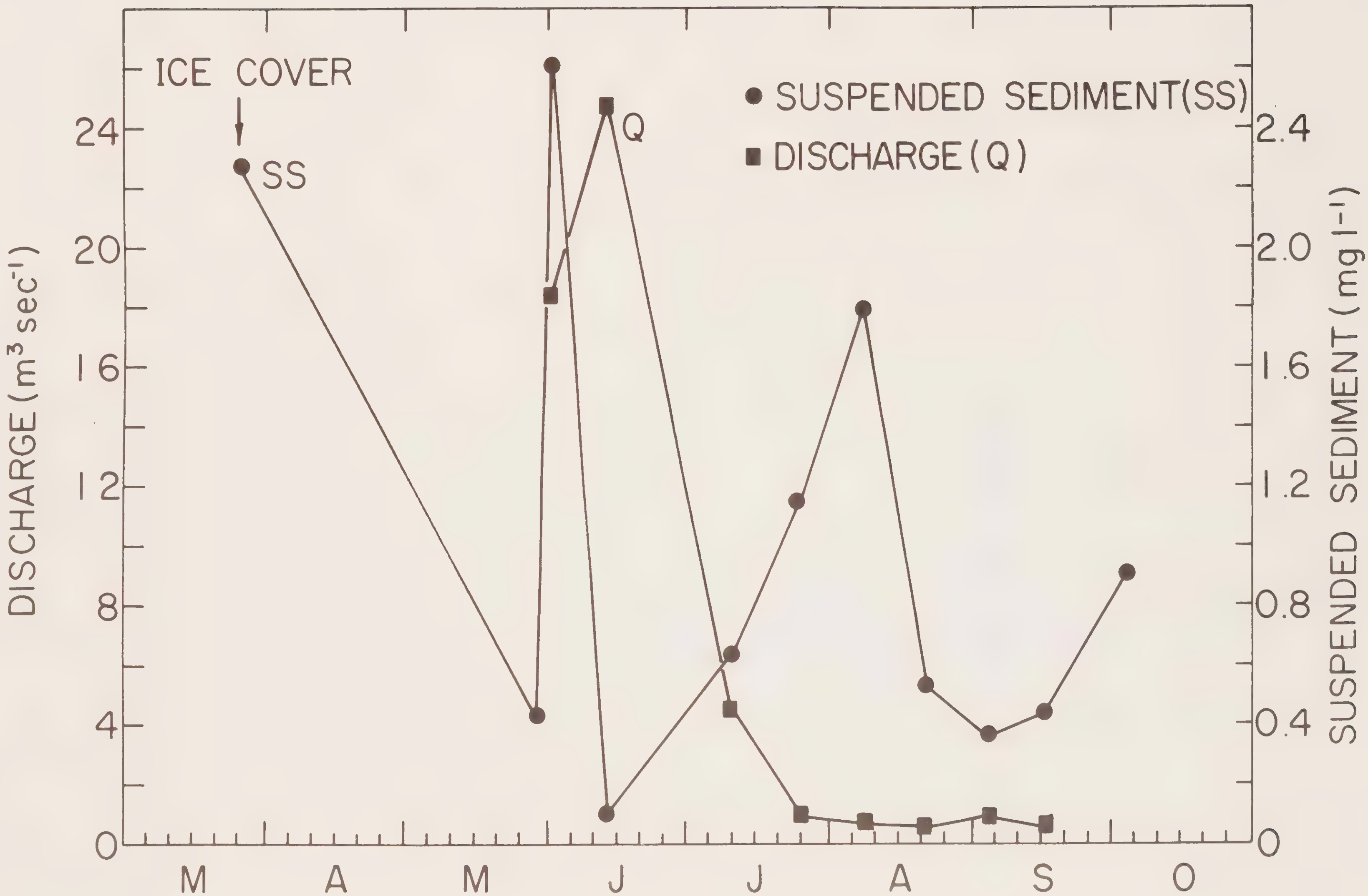


Figure 8b. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Jean Marie Creek at Mackenzie River (1972).

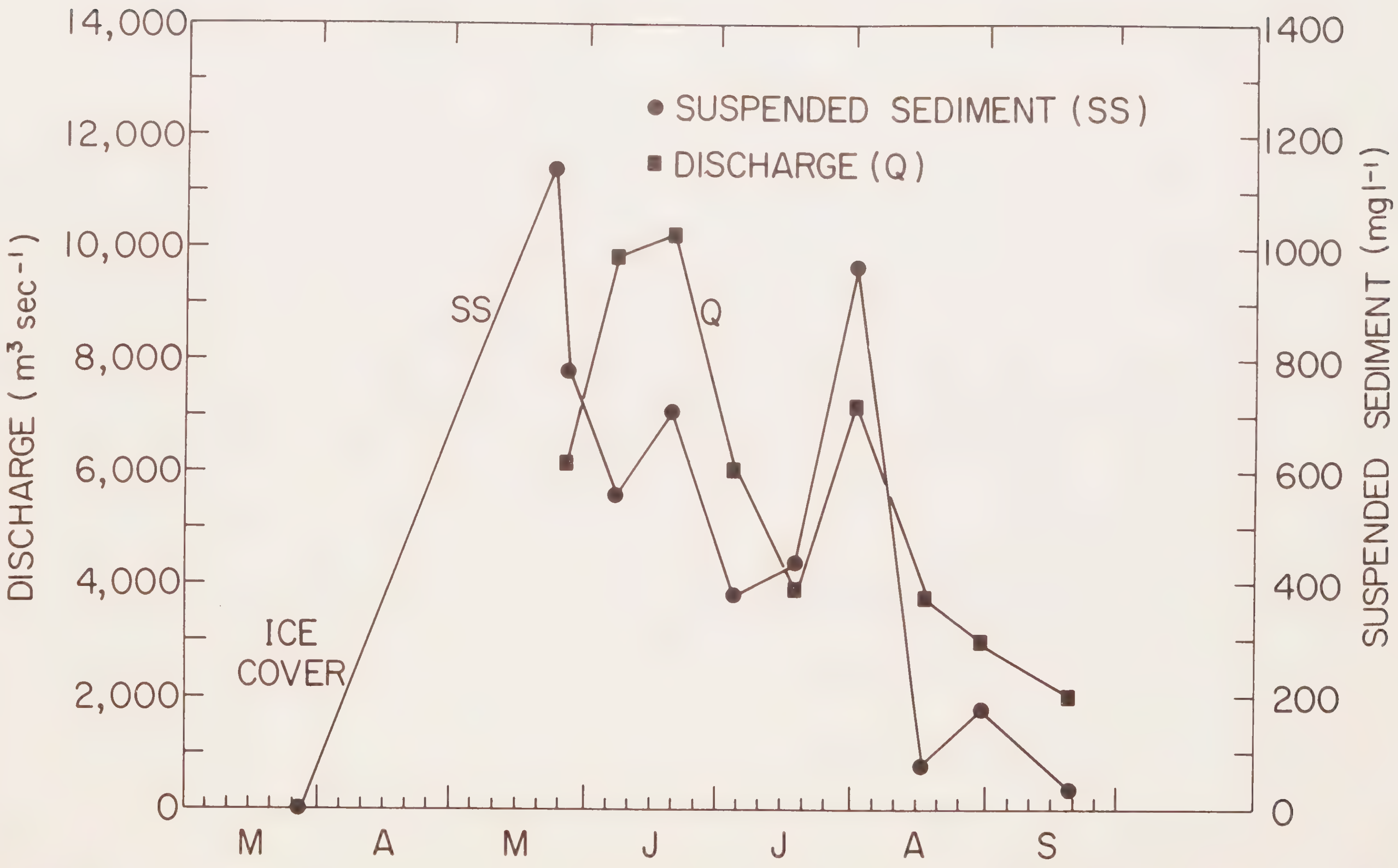


Figure 8c. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Liard River at Fort Simpson (1972).

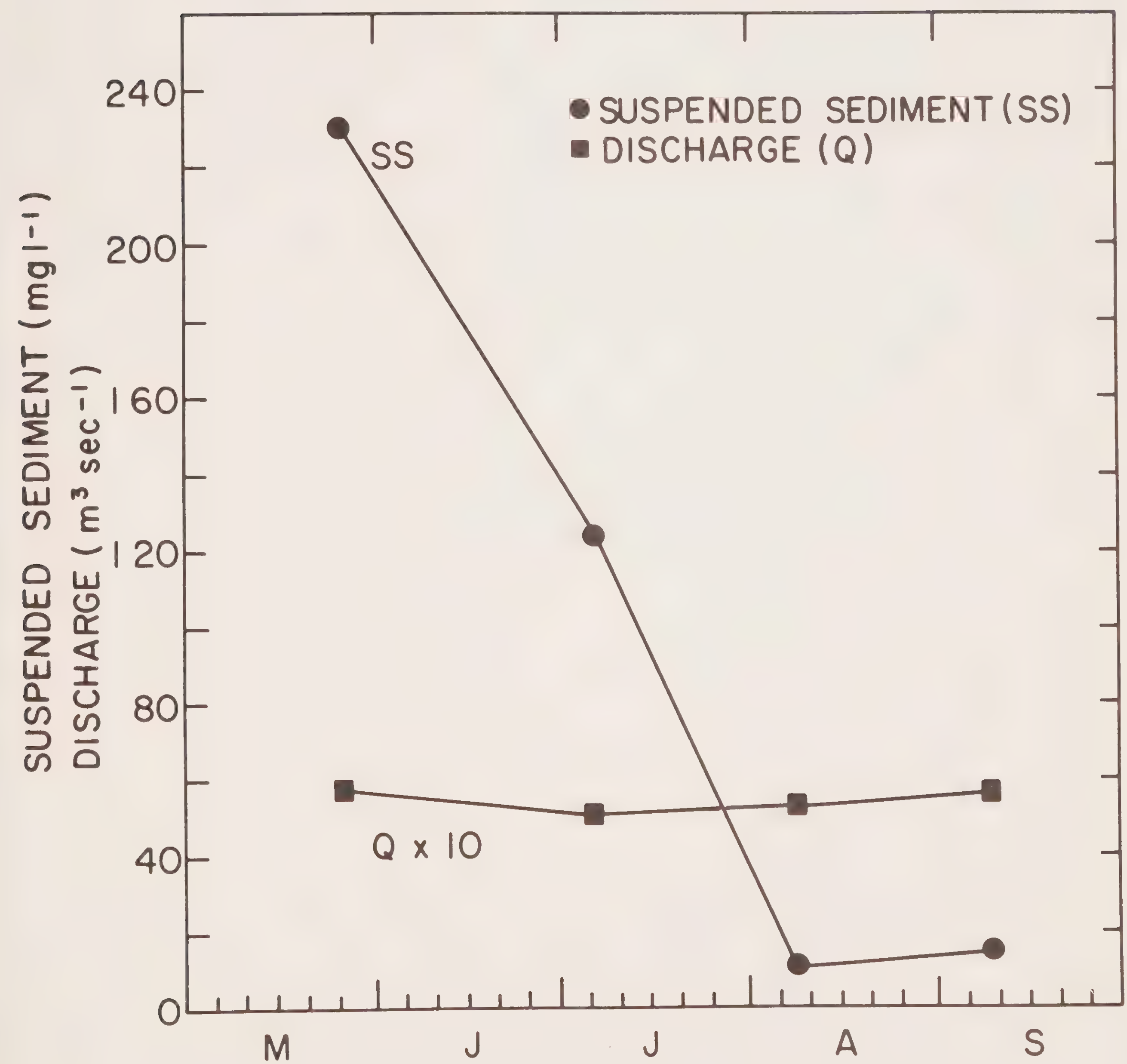


Figure 8d. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Mackenzie River above Fort Simpson (1971).

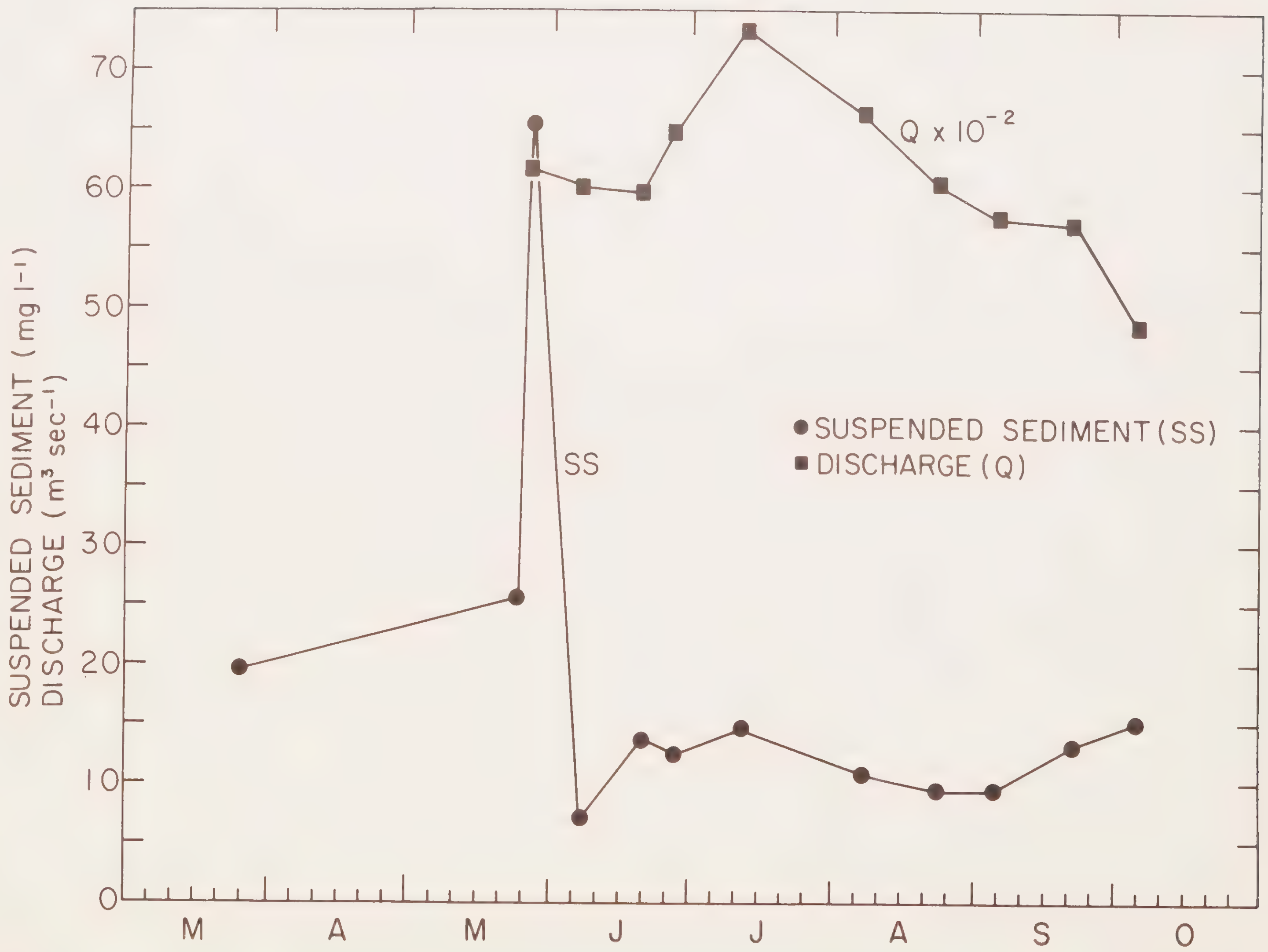


Figure 8e. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Mackenzie River above Fort Simpson (1973).

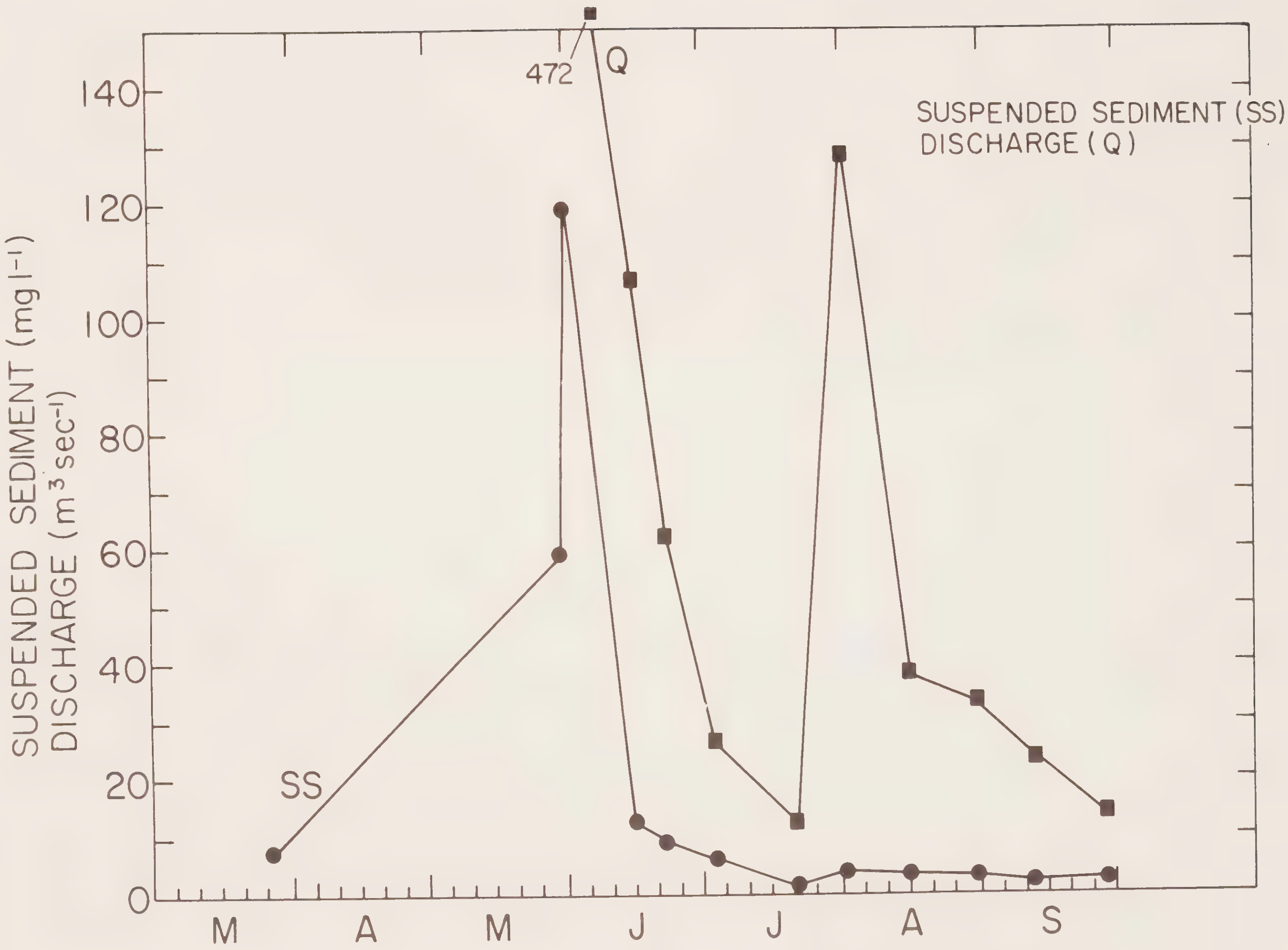


Figure 8f. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Martin River at Mackenzie River (1972).

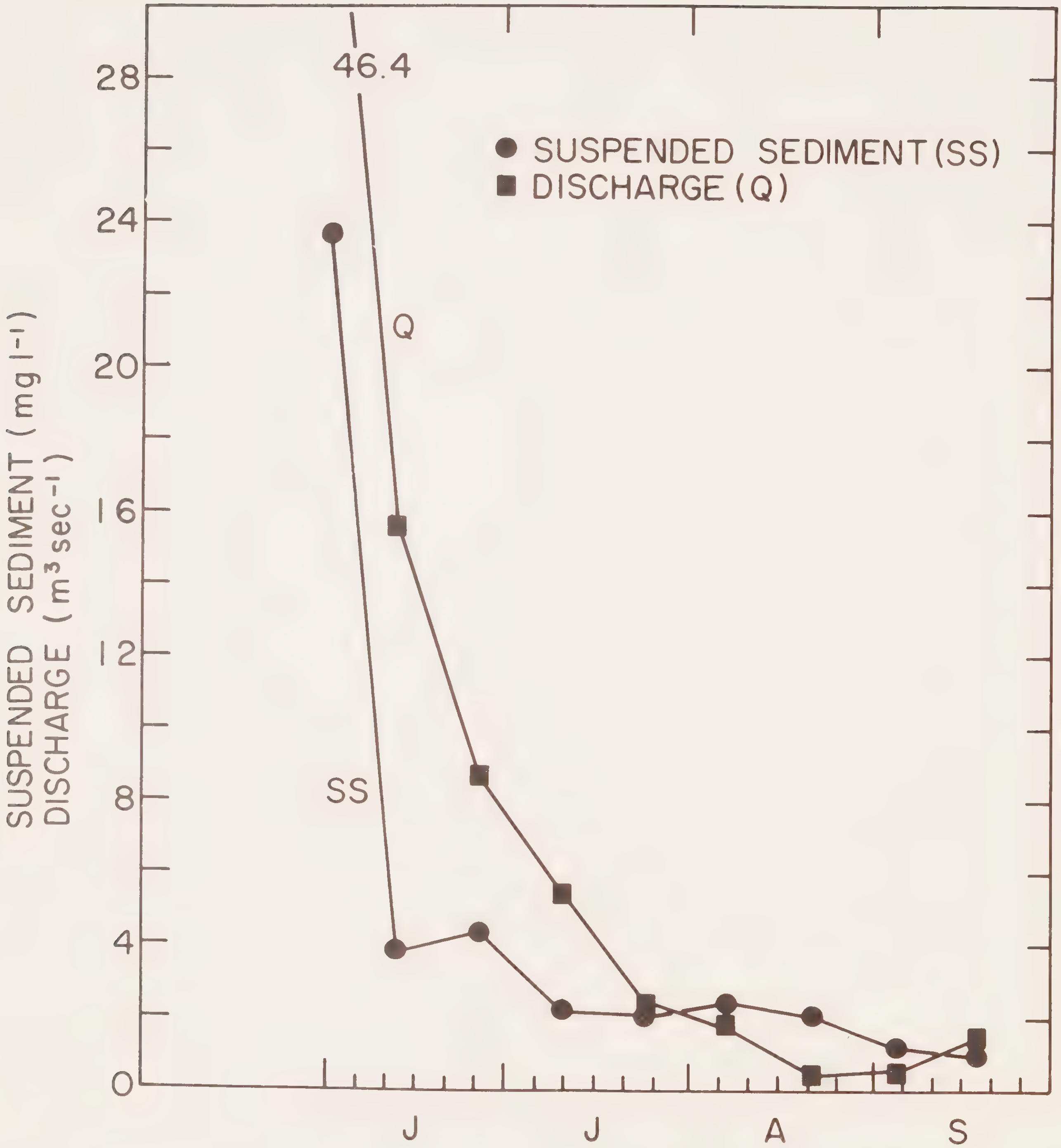


Figure 8g. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Rabbitskin River at Mackenzie River (1972).

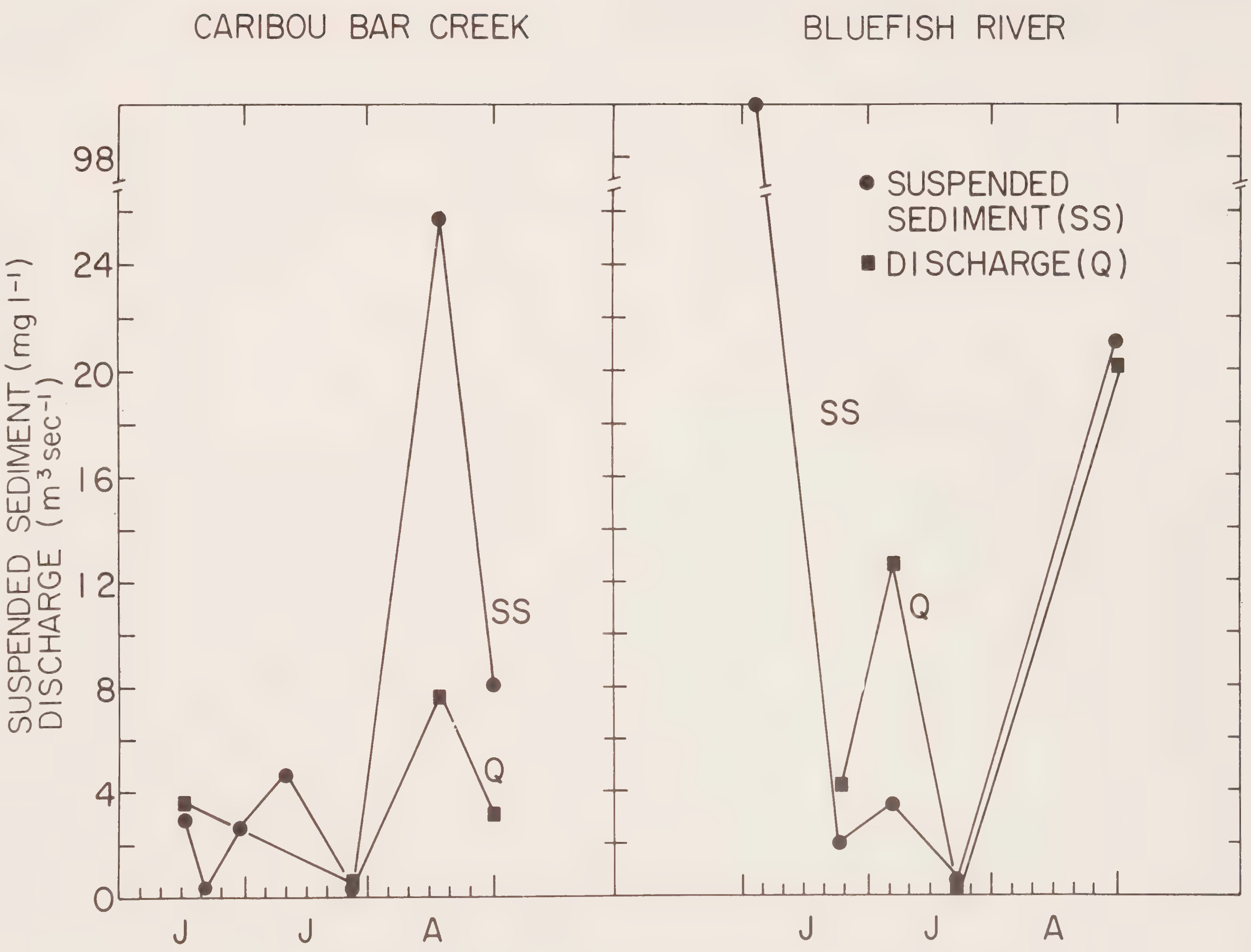


Figure 8h. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Bluefish River and Caribou Bar Creek (1972).

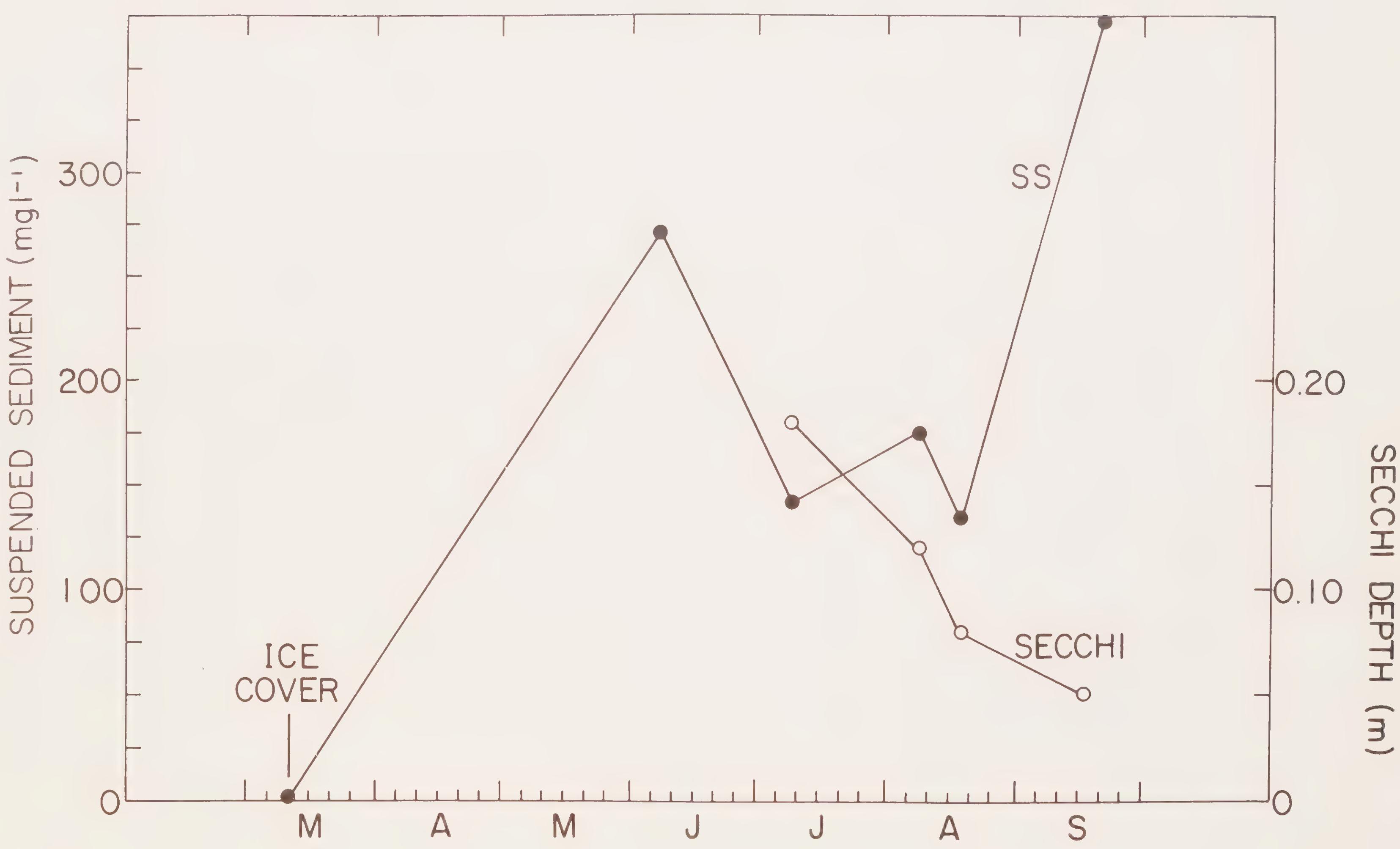


Figure 8i. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Kugmallit Bay - KU4 (1972).

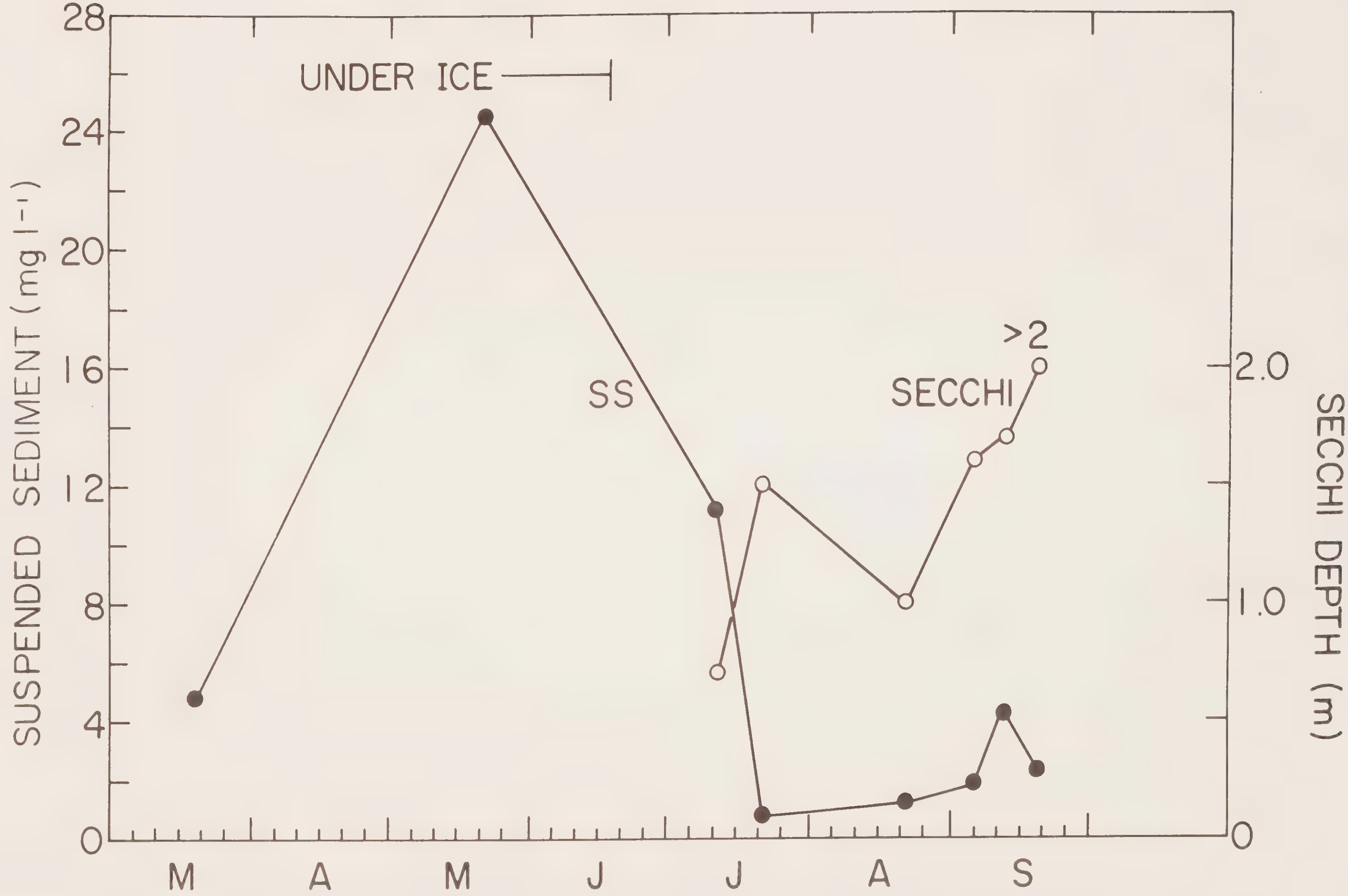


Figure 8j. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Lake 4 (1972).

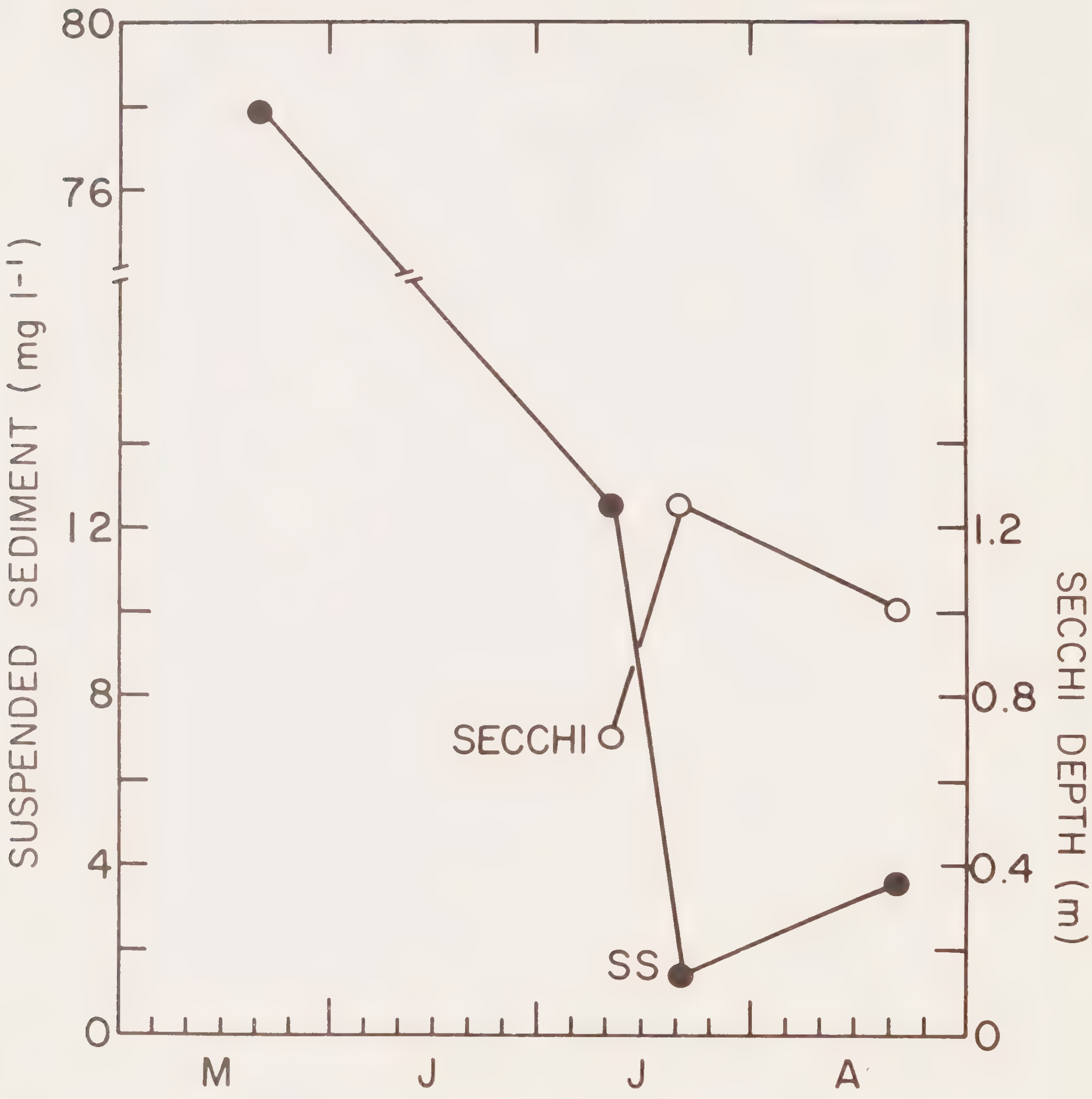


Figure 8k. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Lake C4 (1972).

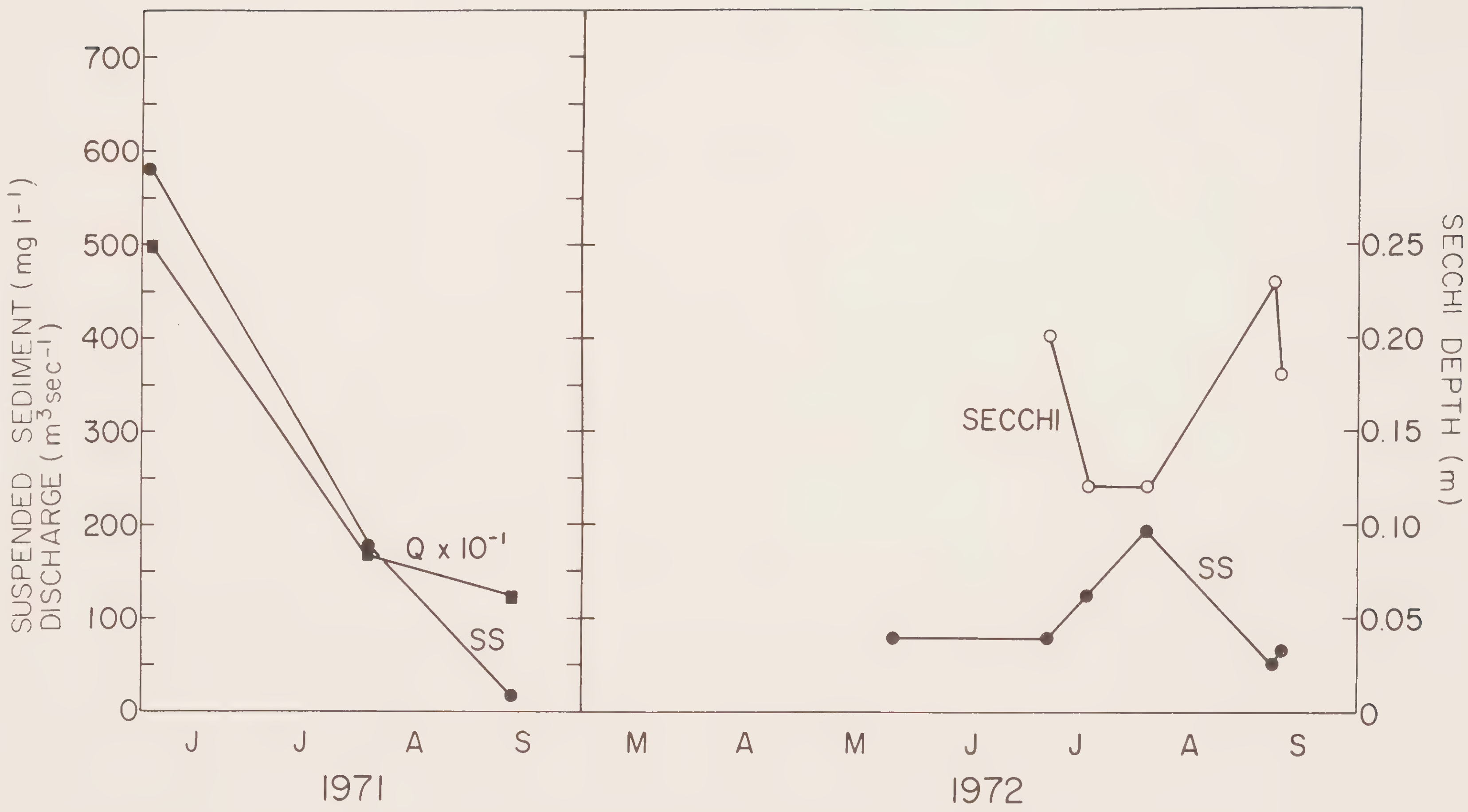


Figure 81. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Peel River at Fort McPherson (1971-72).

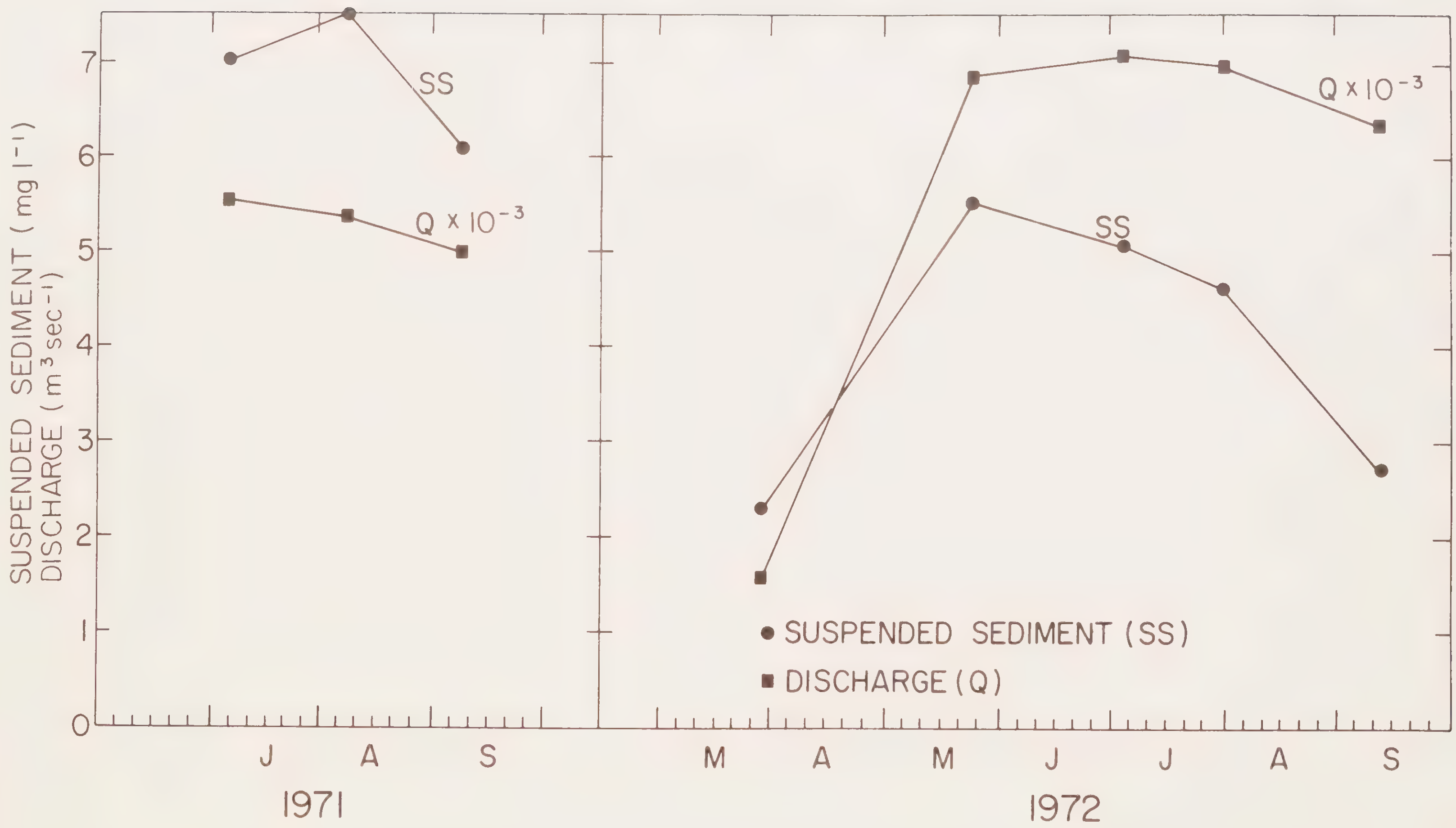


Figure 8m. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Mackenzie River at Fort Providence (1972).

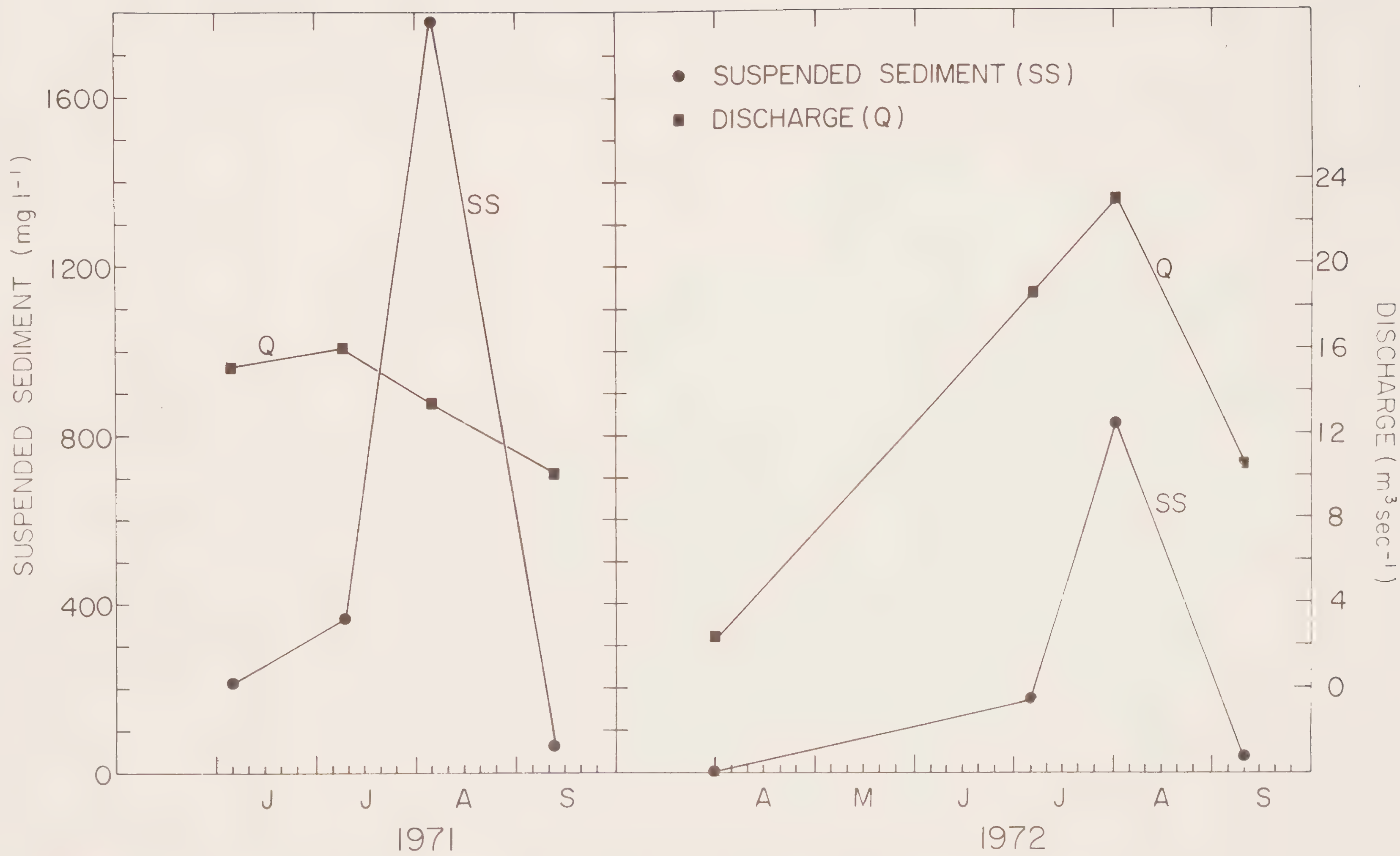


Figure 8n. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Mackenzie River at Norman Wells (1972).

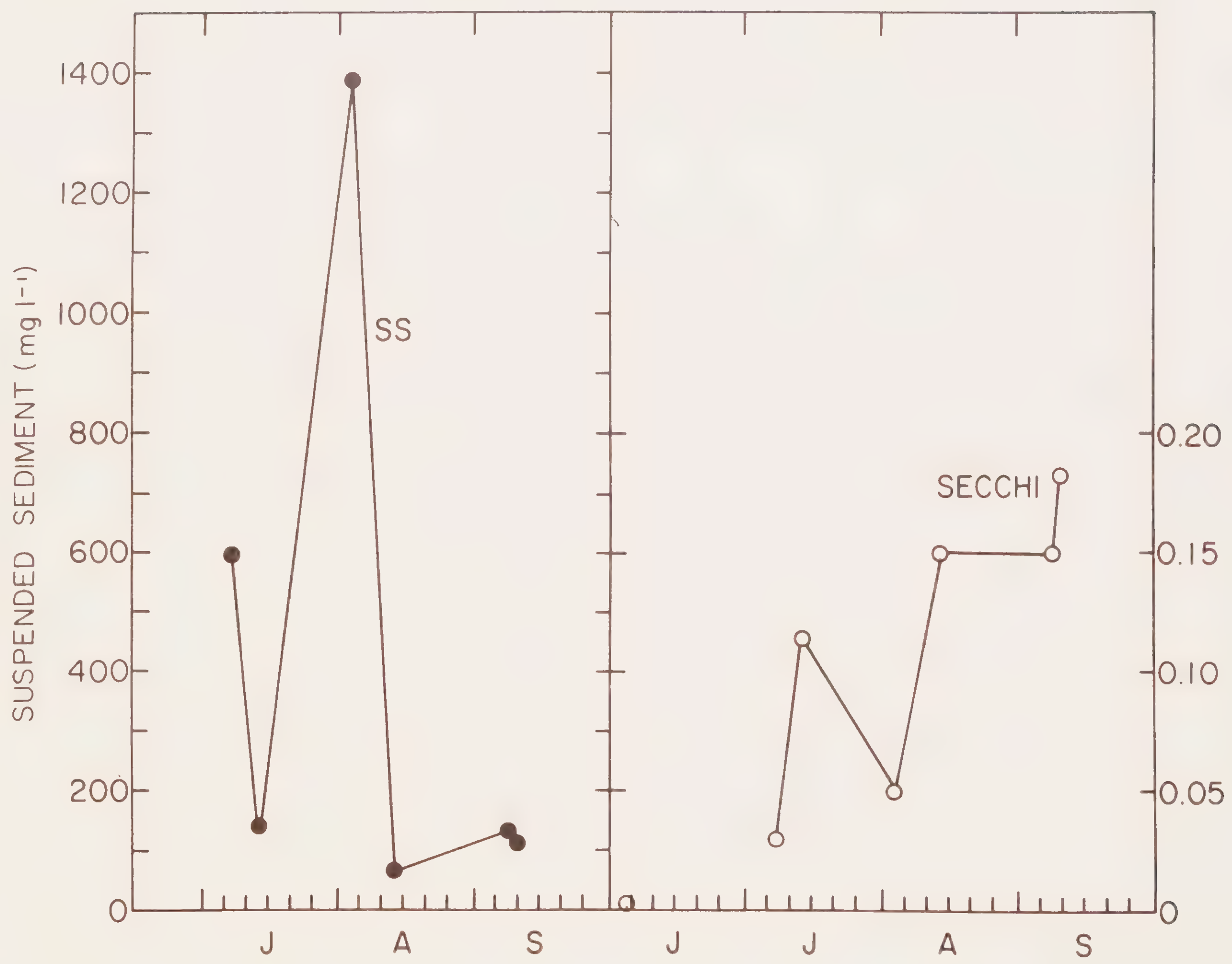


Figure 8o. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Mackenzie River at Arctic Red River (1972).

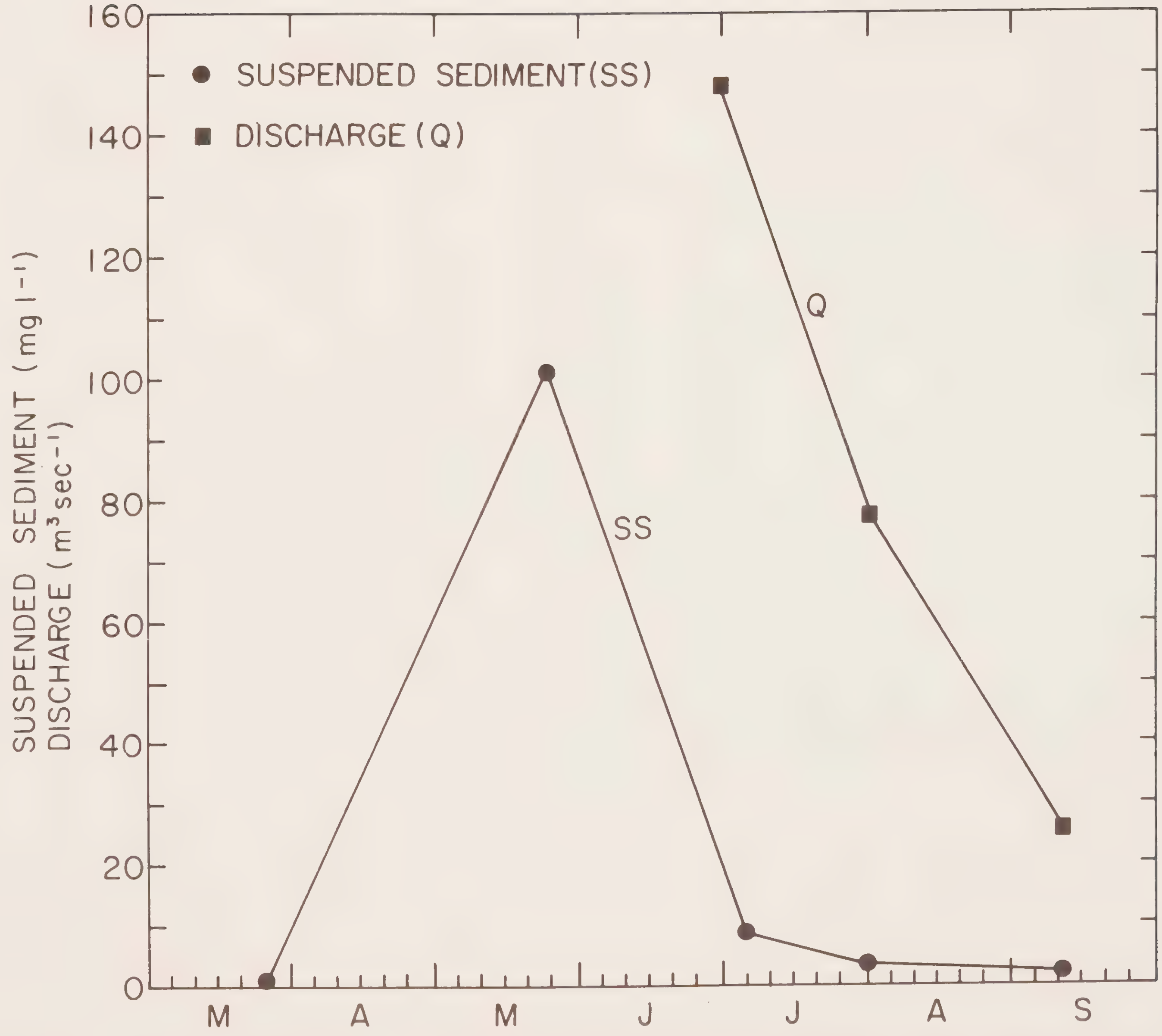


Figure 8p. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Willowlake River (1972).

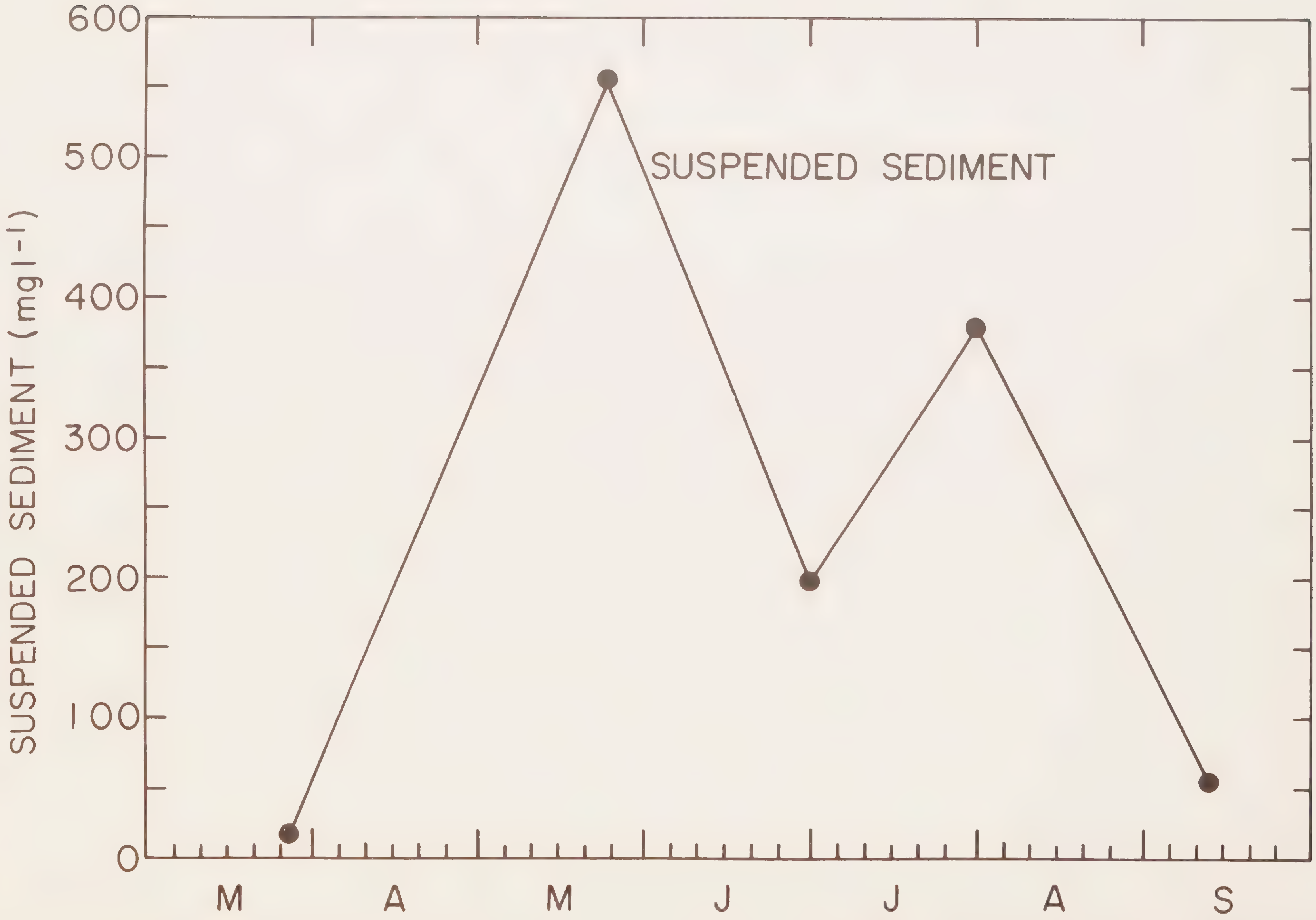


Figure 8q. Seasonal variation in concentration of suspended sediment (SS), and rate of discharge (Q); also Secchi depth where useful. Liard River at Fort Liard (1972).

APPENDIX X

Rates of transport of dissolved and suspended elements at selected stations in the Mackenzie and Porcupine watersheds, 1971-72.

Table Ia Ranges of daily rates of transport of total dissolved calcium, magnesium, sodium and potassium observed during 1971-72. Mackenzie mainstem rivers and streams.

	(metric tons day^{-1})			
LOCATION	Ca	Mg	Na	K
Arctic Red R.	600-1500	220-410	54-110	9.3-38
Great Bear R. (Gt. Bear L.)	650-820	310-350	140-210	30-43
Harris R.	0.05-21	0.02-6.9	0.02-2.7	0.002-0.84
Jean Marie Ck.	2.3-61	0.60-23	0.30-8.3	0.04-1.6
Johnny Hoe R.	60-430	28-160	15-67	2.4-14
Liard R. (Ft. Liard)	4900-9200	1500-2600	380-1400	130-370
Liard R. (Mackenzie R.)	7100-21000	2000-5200	460-1800	110-520
Mackenzie R. (Ft. Providence)	4200-18000	950-4200	1200-4500	180-690
Mackenzie R. (Above Liard R.)	12000-20000	2300-5300	3000-5100	320-940
Mackenzie R. (Norman Wells)	25000-66000	7300-12000	5200-9800	270-1700
Martin R.	5.1-84	1.1-23	0.44-18	0.07-5.6
Peel R.	3300-11000	1300-2700	440-740	86-320
Rabbitskin R.	1.1-130	0.30-47	0.23-30	0.03-8.8
Redstone R.	690-1300	280-460	140-200	14-43
S. Nahanni (Virgin Falls)	490-740	150-180	15-34	12-23
S. Nahanni (Clausen Ck.)	990-3000	320-740	36-130	25-46
Trail R. (Mackenzie)	0.74-11	0.21-3.1	0.24-4.1	0.04-0.39
Trout R.	19-410	3.8-79	2.3-44	0.74-1.4
Willowlake R.	75-2500	26-220	150-500	4.0-22

Table Ib Ranges of daily rates of transport of total dissolved calcium, magnesium, sodium and potassium observed during 1971-72. Yukon rivers and streams.

LOCATION	(metric tons day^{-1}) Ca	Mg	Na	K
Bell R.	0.33-46	0.20-10	0.04-9.4	0.01-1.5
Bluefish R.	3.4-37	0.75-10	0.24-1.7	0.12-0.38
Caribou Bar Ck.	0.02-4.8	0.003-1.9	0.008-0.70	0.0009-0.10
Driftwood R.	2.0-3.1	0.96-2.1	0.86-0.87	0.24-0.27
Joe Ck.	0.09-2.8	0.02-1.1	0.19-0.48	0.05-0.22
Lord Ck.	3.3-5.0	1.0-1.2	0.40-0.53	0.18-0.18
Old Crow R.	74	3.8	2.6	0.44

Table Ic Ranges of daily rates of transport of total dissolved calcium, magnesium, sodium and potassium observed during 1971-72. Mackenzie Delta channels, rivers and streams.

LOCATION	(metric tons day^{-1}) Ca	Mg	Na	K
Anderson R.	310-2300	150-780	120-380	26-110
Campbell Ck.	0.41-1.5	0.16-0.50	0.07-0.45	0.02-0.23
East CH - 1	920	241	160	40
East CH - 3	110-450	32-120	29-79	3.8-19
Rengleng R.	1.7-2.0	0.59-1.9	0.59-4.5	0.12-0.14

NOTE: CH = Channel
3 = Station No. 3

Table IIa Ranges of daily rates of transport of total dissolved sulfate, chloride, bicarbonate, nitrogen, phosphorous and silica observed during 1971-72. Mackenzie mainstem rivers and streams.

	(metric tons day^{-1})					
LOCATION	SO_4	Cl	HCO_3	N	P	Si
Arctic Red R.	620-4400	0.00-120	2700-4500	1.7-12	<0.57-4.5	14-37
Great Bear R. (Gt. Bear L.)	470-1600	210-220	2800-3700	4.9-8.3	0.06-9.2	22-55
Harris R.	0.05-14	<0.0003-0.29	0.22-46	0.0007-0.73	0.00001-0.12	0.002-1.40
Jean Marie Ck.	0.76-29	0.09-2.6	10-270	0.001-1.5	0.0005-0.064	0.09-5.0
Johnny Hoe R.	48-660	11-73	290-1800	10-21	0.84-1.1	12-38
Liard R. (Ft. Liard)	2700-12000	97-390	22000-33000	13-73	8.2-18	150-380
Liard R. (Mackenzie R.)	4700-14000	<107-760	31000-160000	43-530	2.8-19	410-1700
Mackenzie R. (Ft. Providence)	6700-13000	3100-5200	15000-60000	40-260	0.48-9.3	190-940
Mackenzie R. (Above Liard R.)	7600-19000	1800-5200	43000-68000	35-360	6.4-21	230-1200
Mackenzie R. (Norman Wells)	20000-81000	3100-7900	29000-230000	110-900	1.3-97	360-3500
Martin R.	1.2-72	<0.07-3.3	21-320	0.07-3.3	0.001-0.076	0.32-7.2
Peel R.	3700-26000	200-860	13000-37000	12-77	3.0-32	64-210
Rabbitskin R.	0.62-240	0.02-18	4.6-340	0.001-4.1	0.0007-0.087	0.03-7.7
Redstone R.	670-950	34-280	2700-9900	1.7-3.8	0.22-1.1	10-57
S. Nahanni (Virginia Falls)	350-1100	6.7-30	2000-3800	1.6-4.4	0.24-1.0	14-44
S. Nahanni (Clausen Ck.)	700-2500	0.0-9.0	3900-11000	2.4-18	0.35-5.5	23-140
Trail R. (Mackenzie)	0.53-10	<0.03-2.2	4.5-35	0.002-0.42	0.0003-0.035	0.08-1.2
Trout R.	6.3-150	0.0-180	83-1400	0.14-10	0.01-0.26	0.31-33
Willowlake R.	42-570	150-490	250-2500	0.29-8.5	0.03-0.98	2.4-21

Table IIb Ranges of daily rates of transport of total dissolved sulfate, chloride, bicarbonate, nitrogen, phosphorous, and silica observed during 1971-72. Yukon rivers and streams.

			(metric tons day^{-1})			
LOCATION	SO_4	Cl	HCO_3	N	P	Si
Bell R.	0.51-58	0.67-5.3	0.92-73	0.0005-1.6	0.0001-0.033	0.007-4.4
Bluefish R.	1.2-8.4	<0.12-1.2	54-160	0.13-0.63	0.004-0.021	0.46-1.3
Caribou Bar Ck.	0.02-3.9	<0.004-0.21	0.09-14	0.002-0.28	0.00004-0.007	0.01-2.1
Driftwood R.	4.3-7.2	0.23-1.1	7.6-12	0.11-0.31	0.008-0.009	0.44-0.76
Joe Ck.	0.46-0.98	<0.09-0.14	6.4-13	0.09-0.10	0.002-0.008	0.08-0.16
Lord Ck.	2.3-3.5	<0.14-0.17	13-20	0.07-0.25	0.005-0.007	0.31-0.74
Old Crow R.	31	<0.59	260	0.84	0.05	2.1

Table IIc Ranges of daily rates of transport of total dissolved sulfate, chloride, bicarbonate, nitrogen, phosphorous and silica observed during 1971-72. Mackenzie Delta channels, rivers and streams.

			(metric tons day^{-1})			
LOCATION	SO_4	Cl	HCO_3	N	P	Si
Anderson R.	210-2600	160-450	1700-9000	1.9-30	0.33-4.3	14-63
Campbell Ck.	0.50-1.9	0.07-0.19	1.5-3.7	0.02-0.12	0.00007-0.004	0.008-0.13
East CH - 1	530	120	3700	21	1.2	43
East CH - 3	95-370	43-81	450-1700	1.1-5.4	0.06-0.91	5.1-24
Rengleng R.	1.2-1.2	0.59-3.9	8.3	0.04-0.06	0.0018-0.0021	0.07-0.08

NOTE: CH = Channel
3 = Station No. 3

Table IIIa Ranges of daily rates of transport of total suspended sediment, and total suspended carbon, nitrogen, and phosphorous observed during 1971-72 (C, N, and P based on analyses of filtered suspended sediment). Mackenzie mainstem rivers and streams.

LOCATION	Total	C	N	P
	(metric tons day^{-1})			
Arctic Red R.	2700-41000	120-770	5.5-43	1.8-27
Great Bear R. (Gt. Bear L.)	0.93-13	8.0-68	2.8-3.4	0.17-0.98
Harris R.	0.0005-2.6	0.0009-0.81	0.0001-0.078	0.000006-0.012
Jean Marie Ck.	0.02-4.1	0.05-2.9	0.003-0.24	0.0004-0.023
Johnny Hoe R.	3.5-58	1.0	0.08	0.01
Liard R. (Ft. Liard)	1300-39000	16-910	1.6-82	11-37
Liard R. (Mackenzie R.)	6900-620000	2200-13000	29-610	1.4-128
Mackenzie R. (Ft. Providence)	320-3500	130-1400	11-120	3.0-15
Mackenzie R. (Above Liard R.)	4000-110000	260-4800	17-100	2.6-100
Mackenzie R. (Norman Wells)	740-2100000	160-88000	10-2900	4.6-980
Martin R.	0.08-490	0.11-2.2	0.008-0.12	0.001-0.22
Peel R.	1600-250000	45-4700	3.4-3000	1.6-22
Rabbitskin R.	0.05-95	0.04-2.6	0.003-0.21	0.0004-0.11
Redstone R.	760-40000	23-1200	0.97-56	0.68-19
S. Nahanni (Virginia Falls)	120-1900	4.4-98	0.20-3.8	0.10-1.4
S. Nahanni (Clausen Ck.)	520-26000	8.5-1200	2.7-41	0.26-12
Trail R. (Mackenzie)	0.02-1.6	0.02-0.59	0.001-0.062	0.0002-0.0043
Trout R.	0.9-190	0.15-25	0.006-1.7	0.003-0.39
Willowlake R.	4.2-780	3.0-29	0.20-1.9	0.02-0.31

Table IIIb Ranges of daily rates of transport of total suspended sediment, and total suspended carbon, nitrogen and phosphorous observed during 1971-72 (C, N, and P based on analyses of filtered suspended sediment). Yukon rivers and streams.

	(metric tons day^{-1})			
LOCATION	Total	C	N	P
Bell R.	0.03-130	0.02-13	0.004-1.9	0.003-0.21
Bluefish R.	0.15-3.7	0.31-0.91	0.03-0.14	0.002-0.007
Caribou Bar Ck.	0.004-17	0.005-0.26	0.0003-0.025	0.00003-0.0037
Driftwood R.	1.2-1.2	0.33-0.72	0.08-0.50	0.004-0.006
Joe Ck.	0.26-3.0	0.14-0.46	0.01-0.05	0.002-0.007
Lord Ck.	0.62	0.19-0.26	0.02-0.04	0.002-0.003
Old Crow R.	27	3.7	0.48	0.04

Table IIIc Ranges of daily rates of transport of total suspended sediment and total suspended carbon, nitrogen and phosphorous observed during 1971-72 (C, N, and P based on analyses of filtered suspended sediment). Mackenzie Delta channels, rivers and streams.

	(metric tons day^{-1})			
LOCATION	Total	C	N	P
Anderson R.	140-38000	830	45	14
Campbell Ck.	0.15-2.6	0.05-0.19	0.003-0.028	0.0005-0.0038
East CH - 1	17000		16	2.7
East CH - 3	3.1-9700	120	9.9	1.6

NOTE: CH = Channel
3 = Station No. 3

Table IVa Ranges of daily rates of transport of total suspended carbon, nitrogen, phosphorous and carbonate (inorganic) carbon observed during 1971-72 (C, N, and P based on analyses of centrifuged suspended sediment). Mackenzie mainstem rivers and streams.

	(metric tons day^{-1})			
LOCATION	C	CO_3-C	N	P
Liard R. (Mackenzie R.)	820-16000	540-12000	69-690	39-330
Mackenzie R. (Norman Wells)	9800-73000	7500-63000	370-2500	120-610
Rabbitskin R.	3.2	1.9	0.22	
Trout R.	0.11	0.08	7.6	

Table Va Ranges of daily rates of transport of total suspended calcium, potassium, silica, aluminum, titanium, iron and manganese observed during 1971-72. Mackenzie mainstem rivers and streams.

	(metric tons day^{-1})						
LOCATION	Ca	K	Si	Al	Ti	Fe	Mn
Arctic Red R.	670	710	8600	2300	130	150	17000
Mackenzie R. (Above Liard R.)	11000 - 22000	7700 - 12000	120000 - 180000	27000 - 41000	1200 - 1700	9400 - 15000	190 - 340
Mackenzie R. (Norman Wells)	17000 - 100000	6000 - 35000	70000 - 380000	100000 - 190000	1100 - 5500	11000 - 56000	170 - 1000

Table VIa Estimations of annual rates of transport of total dissolved calcium, magnesium, sodium and potassium during 1971 from selected Mackenzie mainstem river and stream watersheds.

	(metric tons $year^{-1}$)			
LOCATION	Ca	Mg	Na	K
Arctic Red R.	171000	57400	14600	3930
Great Bear R. (Gt. Bear L.)	245000	113000	56800	12200
Liard R. (Ft. Liard)	1460000	449000	154000	63500
Mackenzie R. (Ft. Providence)	3420000	781000	839000	139000
Mackenzie R. (Above Liard R.)	3190000	806000	871000	146000
Mackenzie R. (Norman Wells)	7410000	2000000	1460000	290000
Peel R.	640000	218000	63400	16700
S. Nahanni (Virginia Falls)	182000	48600	6380	5250
S. Nahanni (Clausen Ck.)	332000	92100	12300	7000
Willowlake R.	81200	12700	76900	1940

Table VIb Estimations of annual rates of transport of total dissolved calcium, magnesium, sodium and potassium during 1971 from selected Mackenzie mainstem river and stream watersheds.

	(kilograms kilometers^{-2} year^{-1})			
LOCATION	Ca	Mg	Na	K
Arctic Red R.	11300	3790	965	260
Great Bear R. (Gt. Bear L.)	1680	775	390	83.7
Liard R. (Ft. Liard)	6580	2020	694	286
Mackenzie R. (Ft. Providence)	3520	804	864	143
Mackenzie R. (Above Liard R.)	3140	793	857	144
Mackenzie R. (Norman Wells)	4720	1270	930	185
Peel R.	9050	3080	897	236
S. Nahanni (Virginia Falls)	12400	3320	436	359
S. Nahanni (Clausen Ck.)	9940	2760	368	210
Willowlake R.	3760	589	3560	89.1

Table VIIa Estimations of annual rates of transport of total dissolved sulfate, chloride, bicarbonate, nitrogen, phosphorous and silica during 1971 from selected Mackenzie mainstem river and stream watersheds.

	(metric tons $year^{-1}$)					
LOCATION	SO_4	Cl	HCO_3	N	P	Si
Arctic Red R.	303000	6300	711000	1010	310	3920
Great Bear R. (Gt. Bear L.)	294000	71000	1100000	1640	1510	12400
Liard R. (Ft. Liard)	1170000	49900	6750000	6500	4350	68900
Mackenzie R. (Ft. Providence)	1910000	997000	12000000	10900	1570	104000
Mackenzie R. (Above Liard R.)	2920000	839000	13500000	15000	2560	105000
Mackenzie R. (Norman Wells)	7950000	1220000	31400000	40000	6100	265000
Peel R.	948000	43400	2520000	3130	680	17800
S. Nahanni (Virginia Falls)	178000	4480	790000	735	145	7870
S. Nahanni (Clausen Ck.)	241000	10000	1560000	1370	390	14300
Willowlake R.	26800	59800	162000	342	24.3	679

Table VIIb Estimations of annual rates of transport of total dissolved sulfate, chloride, bicarbonate, nitrogen, phosphorous and silica during 1971 from selected Mackenzie mainstem river and stream watersheds.

			(kilograms kilometers^{-2} year^{-1})			
LOCATION	SO_4	Cl	HCO_3	N	P	Si
Arctic Red R.	20000	417	47000	66.8	20.5	259
Great Bear R. (Gt. Bear L.)	2020	487	7540	11.2	10.4	85.0
Liard R. (Ft. Liard)	5270	225	30400	29.3	20.0	310
Mackenzie R. (Ft. Providence)	1970	1030	12400	11.2	1.62	107
Mackenzie R. (Above Liard R.)	2870	826	11800	14.8	2.52	103
Mackenzie R. (Norman Wells)	5070	777	20000	25.5	3.89	169
Peel R.	13400	614	35600	44.3	9.62	252
S. Nahanni (Virginia Falls)	12200	306	54000	50.2	9.91	538
S. Nahanni (Clausen Ck.)	7210	299	46700	41.0	11.7	428
Willowlake R.	1240	2770	7510	15.9	1.13	31.5

Table VIIIa Estimations of annual rates of transport of total suspended sediment and total suspended carbon, nitrogen and phosphorus during 1971 from selected Mackenzie mainstem river and stream watersheds.

	(metric tons $year^{-1}$)			
LOCATION	Total	C	N	P
Arctic Red R.	2000000	59000	3290	1760
Great Bear R. (Gt. Bear L.)	2510 ?	12600	1010	197
Liard R. (Ft. Liard)	6020000	163000	11800	7550
Mackenzie R. (Ft. Providence)	778000	41500	4010	909
Mackenzie R. (Above Liard R.)	13100000	428000	11100	9440
Mackenzie R. (Norman Wells)	140000000	5710000	205000	79700
Peel R.	6780000	146000	9670	1950
S. Nahanni (Virginia Falls)	350000	16300	455	244
S. Nahanni (Clausen Ck.)	1640000	80300	3220	1000
Willowlake R.	24600	1180	80.0	27.4

Table VIIIb Estimations of annual rates of transport of total suspended sediment and total suspended carbon, nitrogen and phosphorous during 1971 from selected Mackenzie mainstem river and stream watersheds.

		(kilograms kilometer^{-2} year^{-1})		
LOCATION	Total	C	N	P
Arctic Red R.	132000	3900	218	116
Great Bear R. (Gt. Bear L.)	17.0 ?	86.4	6.93	1.35
Liard R. (Ft. Liard)	27100	734	53.2	34.0
Mackenzie R. (Ft. Providence)	801	42.7	4.13	0.936
Mackenzie R. (Above Liard R.)	12900	421	10.9	9.29
Mackenzie R. (Norman Wells)	89200	3640	131	50.8
Peel R.	95900	2060	137	27.6
S. Nahanni (Virginia Falls)	23900	1110	31.1	16.7
S. Nahanni (Clausen Ck.)	49100	2400	96.4	29.9
Willowlake R.	1140	54.7	3.71	1.27

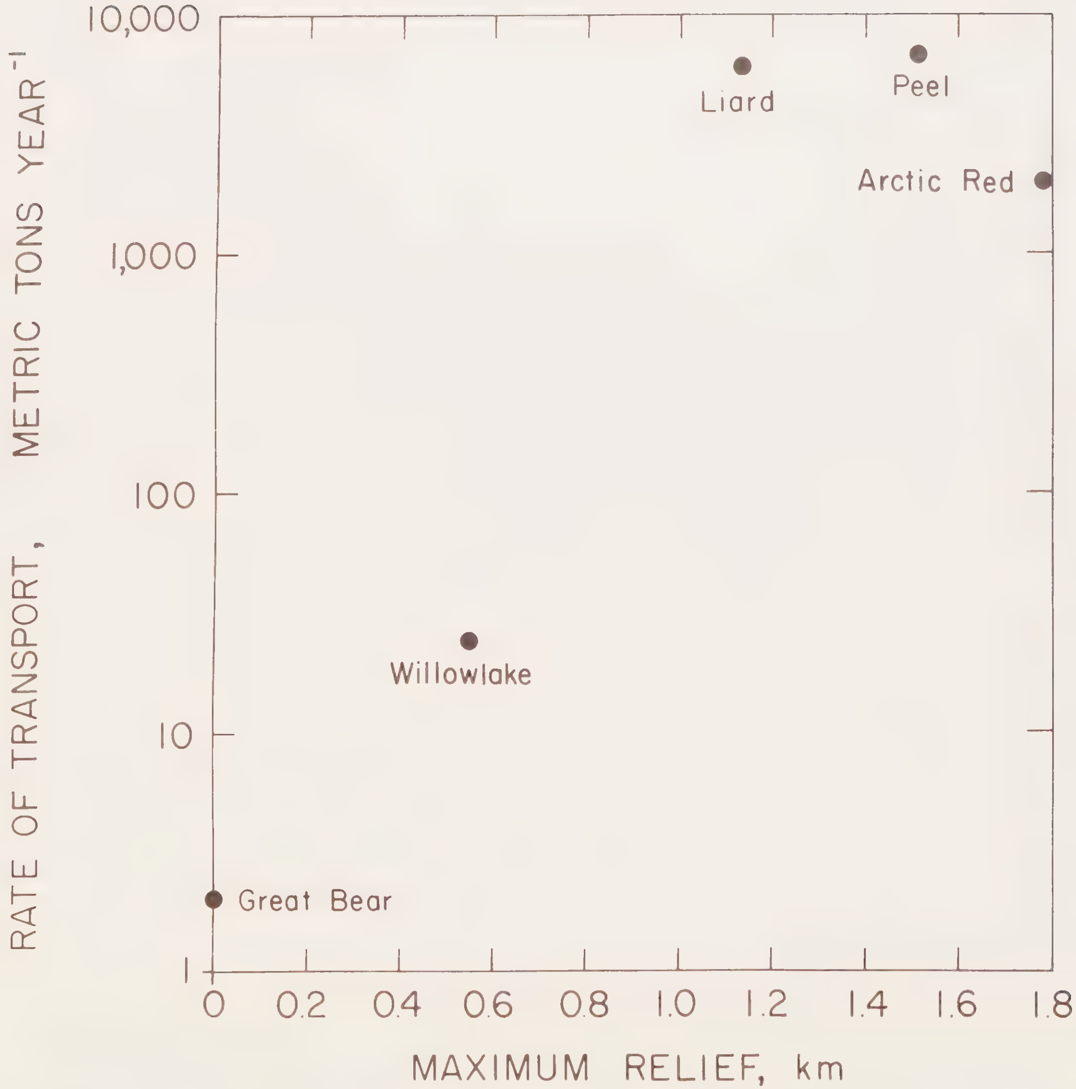


Figure 1. Relation between annual rates of transport of total suspended sediment and maximum reliefs of selected Mackenzie mainstem rivers (1971).

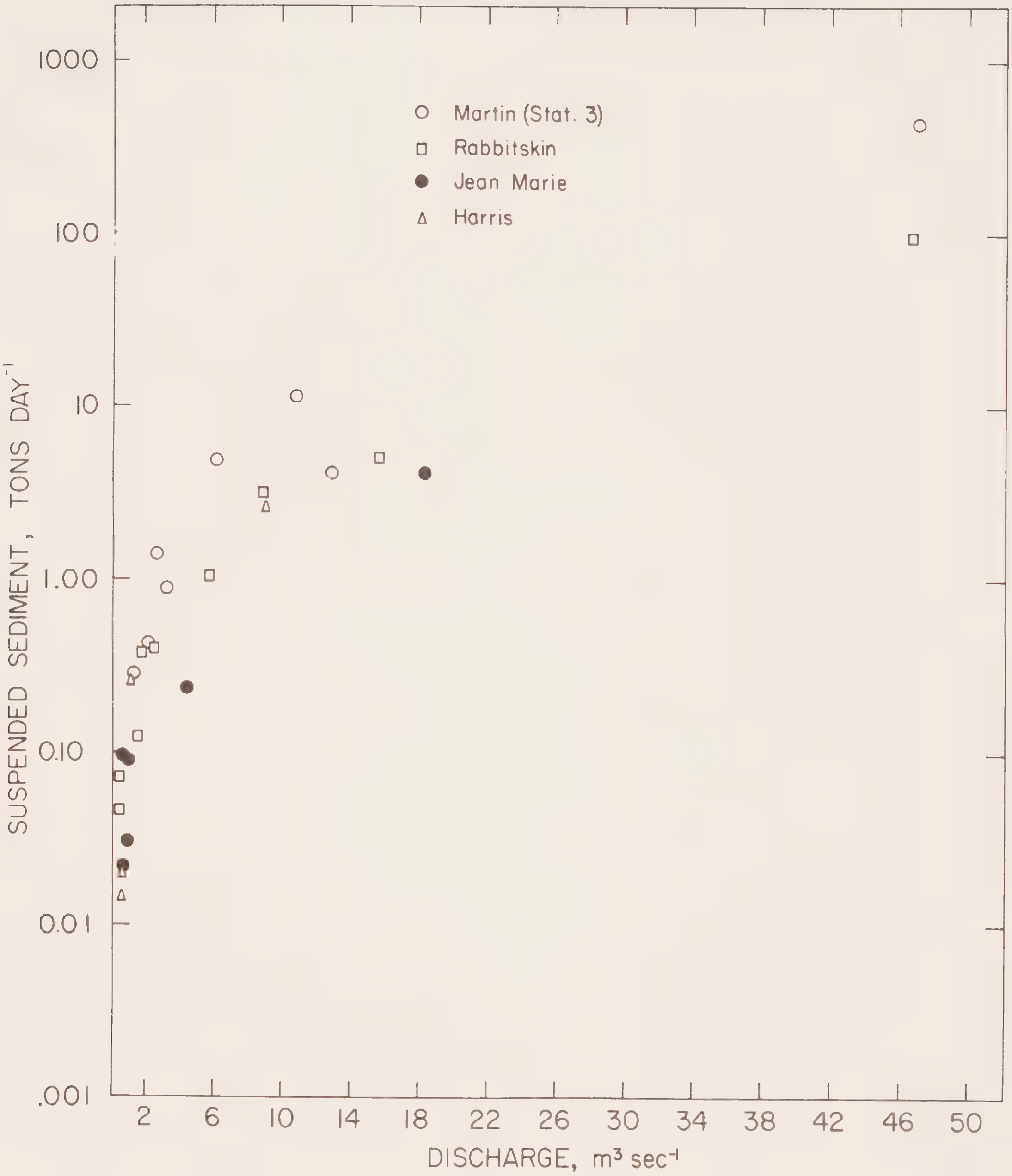


Figure 2. Relation between daily rates of transport of total suspended sediment and corresponding daily rates of discharge for selected Mackenzie mainstem rivers (1971-72).

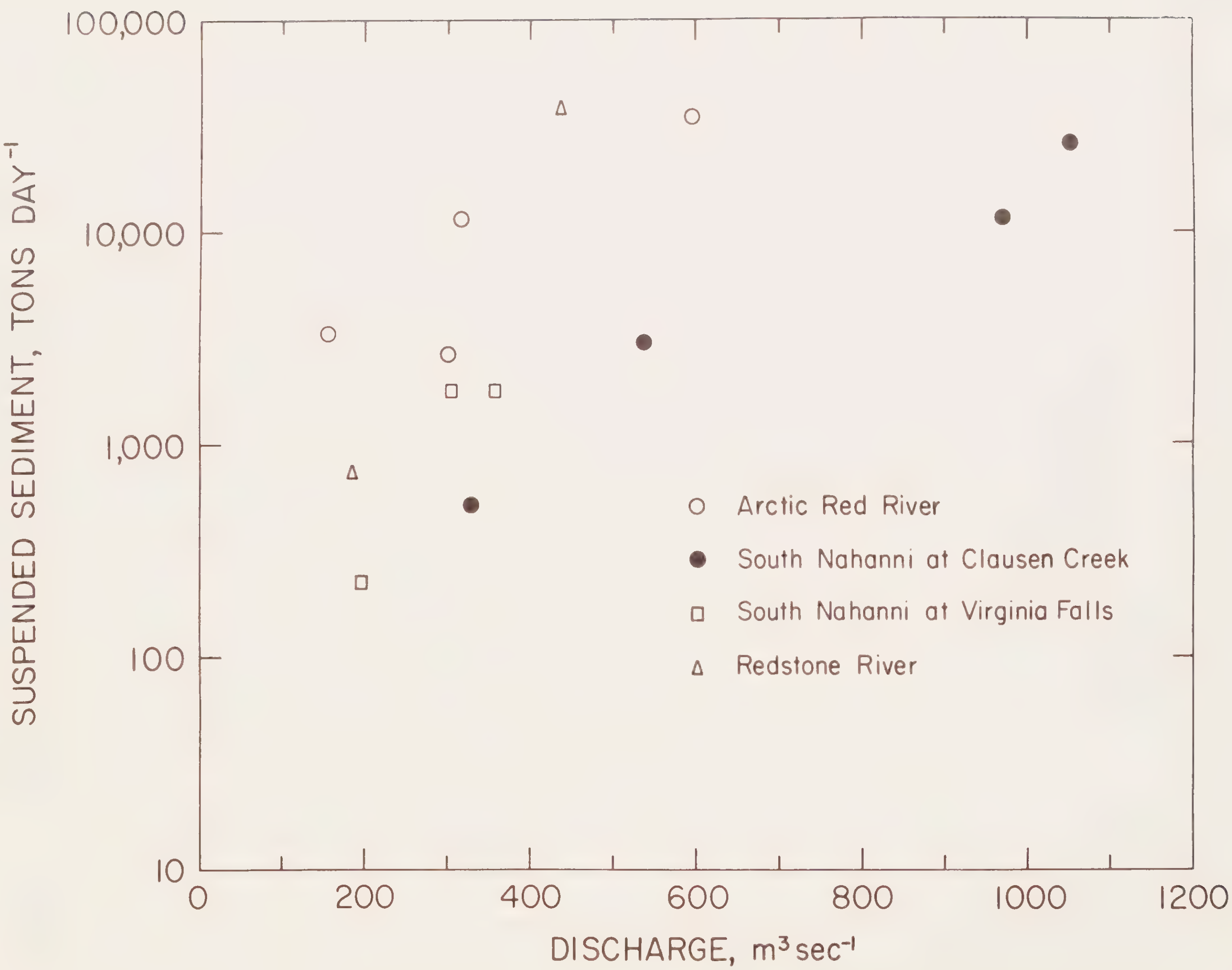


Figure 2 (cont'd)

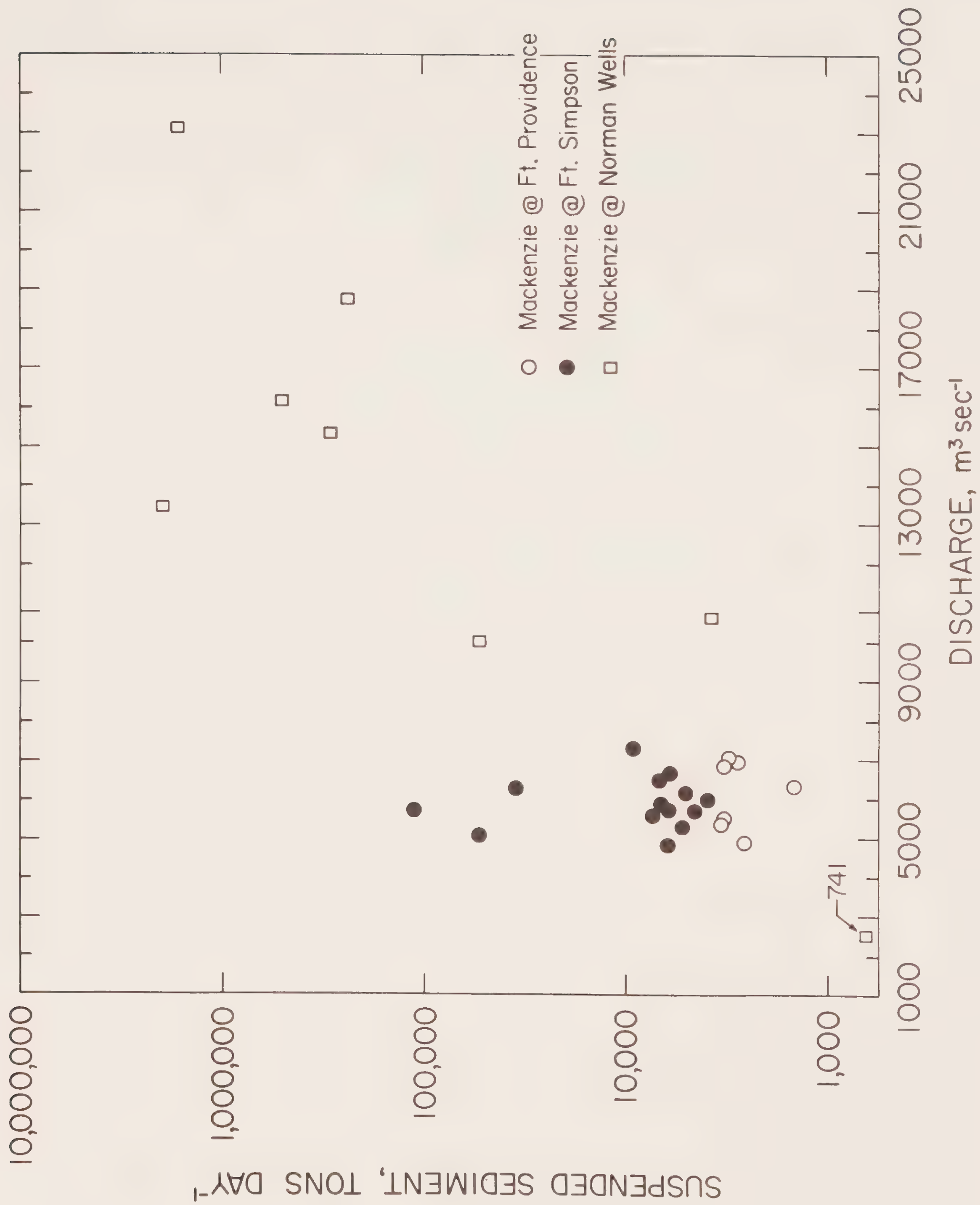


Figure 2 (cont'd)

APPENDIX XI

Physical and chemical properties of Mackenzie-Porcupine watershed sediments, shore, and bank sediments.

Table Ia Major mineral constituents detected, ranges of particle size fractions - sand (2mm - 50μm), silt (50 - 2μm) and clay (<2μm) - and ranges of percent weight of bottom sediments lost upon ignition at 550°C and lost by treatment by 30% H_2O_2 measured during 1971-72. Mackenzie mainstem rivers and streams.

LOCATION	MAJOR MINERALS	SAND (per cent)	SILT (per cent)	CLAY (per cent)	L.O.I. (per cent)	LOSS H_2O_2 (per cent)
Arctic Red R.	1. Quartz 2. Dolomite 3. Calcite 4. Illite 5. Plagioclase	3.0-87	19-26	0.00-9.6	0.50-6.8	
Bluefish R.	1. Quartz 2. Plagioclase 3. Illite	24	58	9.9	7.7	
Brackett R.		54	19	22	5.5	
Caribou R.	1. Quartz 2. Illite 3. Plagioclase 4. Dolomite 5. Calcite	40	35	11	14	
Cranswick R.		100				
Flat R.		99	1.0			
Great Bear R. (Great Bear L.)	1. Dolomite 2. Calcite 3. Quartz 4. Plagioclase 5. Chlorite 6. Illite	44	19	>30		
Great Bear R. (Brackett R.)		44	17	10	6.0	2.9
Hanna R.		42	38	10	8.7	9.8
Hare Indian R.		8.8-100	5.0-41	0.00-14	2.7-15	
Harris R.		44			6.4	
Horn R.					5.5	
Liard R. (Mackenzie R.)		99-100	0.00-0.80	0.00-0.00	3.2-9.8	0.10
Mackenzie R. (Ft. Providence)	1. Dolomite 2. Plagioclase 3. Calcite 4. Quartz				14	
Mackenzie R. (Wrigley)	1. Dolomite 2. Calcite 3. Quartz 4. Plagioclase 5. Chlorite	40	37	3.0	20	12

Table Ia	MAJOR MINERALS	SAND	SILT	CLAY	L.O.I.	LOSS H_2O_2
Mackenzie R. (San Sault Rapids)	1. Dolomite 2. Calcite 3. Quartz 4. Plagioclase 5. Chlorite 6. Illite					
Mackenzie R. (Norman Wells)	1. Quartz 2. Plagioclase 3. Dolomite 4. Calcite 5. Chlorite 6. Illite	6.9	42	46	5.1	
Martin R.	1. Dolomite 2. Plagioclase 3. Quartz 4. Calcite 5. Chlorite	0.90-85	5.0-49	1.0-33	12-12	7.7-16
Mountain R.	1. Dolomite 2. Quartz 3. Calcite 4. Plagioclase 5. Chlorite 6. Illite					
Ontaratue R.	1. Quartz 2. Chlorite 3. Illite	4.5	29	50	17	
Peel R.	1. Dolomite 2. Quartz 3. Plagioclase 4. Chlorite 5. Illite	15-95	3.6-53	0.00-10	2.6-2.2	2.0
Rabbitskin R.		37	7.6	39	12	17
Ramparts R.	1. Chlorite 2. Quartz 3. Plagioclase 4. Illite					
Redstone R.	1. Dolomite 2. Calcite 3. Quartz 4. Chlorite 5. Plagioclase 6. Illite	23-80	11-48	2.9-3.0	2.6-6.9	12
Sainville R.	1. Quartz 2. Illite 3. Plagioclase 4. Dolomite 5. Calcite 6. Chlorite	98	2.0	0.00		
Saline R.		10-50	32-52	17-33	5.0-16	0.80
S. Nahanni (Virginia Falls)	1. Dolomite 2. Calcite 3. Quartz 4. Chlorite 5. Illite 6. Plagioclase	73.0	5.0	0.00	22	
S. Nahanni (Clausen Creek)		6.1-100	0.0-69	0.00-30	3.6	13

Table Ia	MAJOR MINERALS	SAND	SILT	CLAY	L.O.I.	LOSS H_2O_2
Trout R.		7.5	26	46	22	13
Weldon Creek	1. Quartz 2. Chlorite 3. Illite 4. Plagioclase	30-88	0.00-2.0	0.00-0.00		
Willowlake R.	1. Calcite 2. Quartz 3. Dolomite 4. Chlorite 5. Illite 6. Plagioclase	27-62	21-43	6.8-19	10-10	

Table Ib Major mineral constituents detected, ranges of particle size fractions - sand (2mm - 50μm), silt (50 - 2μm) and clay (<2μm) - and ranges of percent weight of bottom sediments lost upon ignition at 550°C and lost by treatment by 30% H_2O_2 measured during 1971-72. Yukon rivers and streams.

LOCATION	MAJOR MINERALS	SAND	SILT	(per cent) CLAY	L.O.I.	LOSS H_2O_2
Bell R.	1. Quartz 2. Plagioclase 3. Illite	12-60	0.00-21	0.00-25	4.6-5.8	2.6-6.7
Bluefish R.	1. Quartz 2. Plagioclase 3. Illite	24	58	9.9	7.7	
Caribou Bar Creek		82	8.8	15	2.8-3.7	4.4
Eagle R.		27	7.2	5.2	11	0.78
Potato Creek	1. Quartz 2. Dolomite 3. Illite 4. Plagioclase 5. Calcite	87	15			
Timber Creek		10-74	0.00-67	0.0-13	9.7	

Table Ic Major mineral constituents detected, ranges of particle size fractions - sand (2 mm - 50μm), silt (50 - 2μm) and clay (<2μm) - and ranges of percent weight of bottom sediment lost upon ignition at 550°C and lost by treatment with 30% H_2O_2 measured during 1971-72. Mackenzie Delta channels and sea, rivers and streams.

LOCATION	MAJOR MINERALS	SAND	SILT	(per cent) CLAY	L.O.I.	LOSS H_2O_2
Aklavik CH - 1		8.5-32	47-67	12-15	8.3-10	
Beaufort Sea - 13	1. Quartz 2. Dolomite 3. Calcite 4. Illite 5. Chlorite 6. Plagioclase	1.4-16	50-60	21-36	2.6-12	
Beaufort Sea - 14		0.90	62	26	11	
Beaufort Sea - 15	1. Quartz 2. Calcite 3. Dolomite 4. Plagioclase 5. Chlorite 6. Illite	1.5-25	49-67	10-37	10-12	3.4-8.8
Beaufort Sea - 18		100				
Beaufort Sea - 19		0.90	56	33	10	
Beaufort Sea - 20		0.80	42	35	23	
Beaufort Sea - 21		28	5.5	9.2	7.6	
Beaufort Sea - 22		9.7	72	8.0	11	
Beaufort Sea - 23		6.0	86	0.60	7.6	
Beaufort Sea - 24	1. Quartz 2. Plagioclase 3. Orthoclase 4. Dolomite 5. Calcite	4.0-75	11-73	3.6-21	5.1-12	1.3-7.9
Beaufort Sea - 26		0.10-7.1	58-79	20-34	8.1-13	2.7-9.3
Campbell Creek		2.5-54	18-42	15-33	5.6-11	3.4-10
East CH - 1		5.2-51	4.5-65	9.2-31	4.9-18	2.1-17
East CH - 3	1. Quartz 2. Dolomite 3. Plagioclase 4. Calcite 5. Chlorite 6. Illite	1.2-40	20-80	12-89	4.6-17	4.1-10

Table Ic	MAJOR MINERALS	SAND	SILT	CLAY	L.O.I.	LOSS H_2O_2
East CH - 4	1. Quartz 2. Dolomite 3. Calcite 4. Plagioclase 5. Chlorite 6. Illite	5.1-89	4.8-78	4.0-60	3.2-21	2.0-11
East CH - 7	1. Quartz 2. Dolomite 3. Calcite 4. Plagioclase 5. Chlorite 6. Illite	0.30-62	25-68	7.6-48	8.2-18	6.0-12
East CH - 8		15-100	0.00-62	0.00-10	12-13	
East CH - 9		11-100	0.00-70	0.00-10	5.6-8.8	
Gully CH - 1		1.5-9.7	70-73	18-19	12-12	1.5-6.9
Hope CH		86	6.8	4.8	2.1	
Jamieson CH - 1		0.9-25	37-68	12-34	9.2-33	1.4-6.5
Jamieson CH - 2		4.4-34	49-76	7.2-16	5.0-12	
Kugmallit Bay - 4	1. Quartz 2. Dolomite 3. Calcite 4. Plagioclase 5. Chlorite 6. Illite	0.12-6.3	58-74	15-38	3.4-39	4.6-11
Kugmallit Bay - 5	1. Quartz 2. Dolomite 3. Calcite 4. Illite 5. Chlorite 6. Plagioclase	0.30-22	44-65	15-50	6.5-13	2.7-13
Kugmallit Bay - 6		6.3	73	10	11	
Kugmallit Bay - 7		22	52	20	6.0	
Kugmallit Bay - 8		6.3	66	21	12	6.9
Kugmallit Bay - 17		16	63	9.6	12	
Main CH - 1	1. Quartz 2. Calcite 3. Plagioclase 4. Dolomite 5. Illite	2.8-76	3.6-67	5.2-25	2.7-21	4.2-14
Main CH - 3		11.3-60	26-68	6.4-12	6.9-13	17
Main CH - 5		63-100	0.00-23	0.00-7.2	0.00-7.2	
Napoiak CH - 1		3.6-63	24-67	6.0-12	9.1-18	1.3-6.2
Peel CH - 1		1.8-7.7	18-33	44-64	6.9-21	
Peel CH - 2		1.9-51	7.6-66	3.6-44	8.1-46	

Table Ic	MAJOR MINERALS	SAND	SILT	CLAY	L.O.I.	LOSS H_2O_2
Peel CH - 3		5.5-7.1	56-69	13-29	9.1-14	
West CH - 1	1. Quartz 2. Dolomite 3. Plagioclase 4. Calcite 5. Chlorite 6. Illite	10-86	6.4-67	2.8-21	2.1-13	0.2-18
West CH - 2		15-52	10-56	6.0-54	7.1-12	1.3-19

NOTE: CH = Channel
3 - Station No. 3

Table Id Major mineral constituents detected, ranges of particle size fractions - sand (2 mm - 50μm), silt (50 - 2μm) and clay (<2μm) - and ranges of percent weight of bottom sediments lost upon ignition at 550°C and lost by treatment with 30% H_2O_2 measured during 1971-72. Mackenzie Delta lakes.

LOCATION	MAJOR MINERALS	SAND (per cent)	SILT	CLAY	L.O.I.	LOSS H_2O_2
East Channel L.		0.63-23	44-70	21-28	6.0-31	4.9-8.7
Shell L.		0.00-20	54-68	24-30	7.5-30	1.5-10
Y Lake		4.7	37	51	7.3	
Lake 1	1. Quartz 2. Dolomite 3. Calcite 4. Chlorite 5. Plagioclase 6. Illite	1.5-7.1	36-71	8.4-55	7.6-14	6.9-14
Lake 2		8.9	59	26	6.7	
Lake 3		0.04-5.6	33-53	33-54	6-25	3.2-20
Lake 4	1. Quartz 2. Dolomite 3. Chlorite 4. Illite	2.3-9.8	1.2-72	5.6-36	5.5-21	1.9-5.3
Lake 4C		1.0-15	50-54	23-41	14-29	7.9
Lake C4		24-31	43-52	10-23	9.0-18	3.8-8.3
Lake 5		0.30-13	23-55	38-66	5.7-13	4.0-8.0
Lake 7		0.80-16	59-76	8.0-41	12-20	0.20-10
Lake 11		0.90-3.1	30-56	32-55	14-21	8.4
Lake 12		5.8-8.2	32-36	47-49	14-27	9.8

Table IIa Ranges of concentrations of total carbon, nitrogen, and phosphorous and of carbonate (inorganic) carbon measured in bottom sediments in 1971-72. Mackenzie mainstem rivers and streams.

LOCATION	(milli moles $gram^{-1}$)			
	C	CO_3-C	N	P
Arctic Red R.	120-400		4.3-20	
Bluefish R.	80		5.7	
Caribou R.	29		2.9	
Great Bear R. (Brackett R.)	0.73	0.80	0.06	0.03
Hare Indian R.	1.4-2.5	1.4-12	0.01-0.03	0.01-0.01
Harris R.	0.38-0.58	0.13	0.06-0.06	0.01-0.02
Horn R.	1.1		0.05	
Liard R. (Mackenzie R.)	0.28	1.3	0.02	0.05
Mackenzie R. (Ft. Providence)				0.01
Mackenzie R. (Wrigley)				0.01
Mackenzie R. (San Sault Rapids)		3.7		0.01
Mackenzie R. (Norman Wells)				0.01
Martin R.	2.6-2.7	1.3-1.6	0.09-0.12	0.01-0.10
Mountain R.		21		0.01
Ontaratue R.	230		5.7	
Peel R.	1.7	0.5-4.6	0.07	0.02
Ramparts R.	6.9		21	
Rabbitskin R.	2.1	1.6	0.07	0.02
Redstone R.				0.01
Sainville R.	2.6		5.0	
Saline R.	3.8	3.2	0.04	0.03

Table IIa	C	CO_3-C	N	P
Secret Creek	32		2.9	
S. Nahanni (Clausen Creek)	5.3	3.9	0.11	0.01
Trout R.		13		
Weldon Creek	230		4.3	
Willowlake R.				0.02

Table IIb Ranges of concentrations of total carbon, nitrogen, and phosphorous and of carbonate (inorganic) carbon measured in bottom sediments during 1971-72. Yukon rivers and streams.

	(milli moles $gram^{-1}$)			
LOCATION	C	CO_3-C	N	P
Bell R.	0.78-1.9	0.06-0.14	0.07-4.3	0.02-0.03
Bluefish R.	80		5.7	
Caribou Bar Creek	0.55-1.7	0.09-0.20	0.05-0.07	0.01-0.03
Driftwood R.	3.3	0.10	0.14	0.05
Potato Creek	78	2.9		

Table IIc Ranges of concentrations of total carbon, nitrogen, and phosphorous and of carbonate (inorganic) carbon measured in bottom sediments during 1971-72. Mackenzie Delta channels and sea, rivers and streams.

LOCATION	C	CO_3-C	N	P
	(milli moles gram^{-1})			
Beaufort Sea - 13	1.4	0.56	0.03	0.01
Beaufort Sea - 15	2.1-2.9	1.4-2.7	0.06-2.7	0.01-0.02
Beaufort Sea - 24	0.65-3.5	0.30-2.3	0.01-0.07	0.02-0.03
Beaufort Sea - 26	1.4-2.9	0.06-2.0	0.04-0.09	0.03-0.03
Campbell Creek	0.50-3.6	0.06-1.4	0.06-0.24	0.02-0.06
East CH - 1	1.7-3.3	0.20-3.3	0.04-0.10	0.01-0.03
East CH - 3	1.2-3.6	0.06-2.3	0.06-0.16	0.02-0.03
East CH - 4	1.0-3.9	1.0-2.2	0.04-0.49	0.01-0.03
East CH - 7	1.1-4.0	0.4-2.7	0.06-0.66	0.02-0.03
Gully CH - 1	2.6-2.9	2.0-2.1	0.07-0.09	0.02-0.03
Jamieson CH - 1	2.4-2.6	1.3-1.3	0.04-0.07	0.02-0.02
Jamieson CH - 2	1.2	0.08		
Kugmallit Bay - 4	1.4-13	0.03-2.2	0.05-1.1	0.02-0.07
Kugmallit Bay - 5	1.8-5.4	0.60-2.1	0.03-0.63	0.02-0.03
Kugmallit Bay - 6	0.42	0.48	0.01	0.50
Kugmallit Bay - 8	2.0	1.2	0.04	0.02
Main CH - 1	1.3-3.9	0.14-2.0	0.04-0.44	0.01-0.03
Main CH - 3	2.7	2.3	0.04	0.02
Napoiak CH - 1	2.5-2.6	0.96-2.2	0.04-0.06	0.02-0.02
Peel CH - 3	0.97		0.12	
West CH - 1	0.60-2.9	0.04-1.3	0.04-0.21	0.02-0.08

Table IIc	C	CO_3-C	N	P
West CH - 2	2.1-2.8	0.8-1.7	0.05-0.14	0.02-0.07
West CH - 3	1.7-3.3	0.30-1.1	0.05-0.09	0.03-0.03

NOTE: CH = Channel
3 - Station No. 3

Table IId Ranges of concentrations of total carbon, nitrogen and phosphorous and of carbonate (inorganic) carbon measured in bottom sediments during 1971-72. Mackenzie Delta lakes.

	(milli moles $gram^{-1}$)			
LOCATION	C	CO_3-C	N	P
East Channel L.	1.5-2.9	1.3-2.2	0.05-0.12	0.02-0.03
Shell L.	5.0-11	0.06-0.25	0.46-0.96	0.02-0.04
Lake 1	0.65-3.4	0.40-1.3	0.09-0.34	0.02-0.03
Lake 2	1.9		0.19	
Lake 3	1.0-2.2	0.30-1.8	0.06-0.12	0.02-0.02
Lake 4	2.0-9.9	0.20-2.9	0.16-1.2	0.01-0.03
Lake 4C	3.6-4.9	1.7	0.10-0.70	0.02
Lake C4	2.8-5.5	0.00-3.1	0.11-0.35	0.02-0.04
Lake 5	1.7-3.5	0.40-1.1	0.16-0.21	0.03-0.04
Lake 7	2.4-4.4	0.06-1.8	0.19-0.28	0.03-0.03
Lake 11	6.8	1.7	0.39	0.02
Lake 12	8.9	0.58	0.72	0.02

Table IIIa Ranges of concentrations of total calcium, potassium, silica, aluminum, titanium, iron and manganese measured in bottom sediments during 1971-72. Mackenzie mainstem rivers and streams.

LOCATION	Ca	K	Si	Al	Ti	Fe	Mn
	(milli moles gram^{-1})						
Hanna R.	1.1	0.42	11	1.6	0.05	0.46	0.01
Hare Indian R.	2.2	0.60	8.0	2.4	0.07	0.57	0.01
Liard R. (Mackenzie R.)	1.2	0.28	11	0.91	0.04	1.2	0.01
Mackenzie R. (Ft. Providence)	1.3	0.35	9.7	1.6	0.05	0.41	0.01
Mackenzie R. (Wrigley)	1.3	0.53	8.3	2.8	0.08	0.95	0.02
Mackenzie R. (San Sault Rapids)	1.5	0.37	8.5	1.6	0.07	0.49	0.01
Mackenzie R. (Norman Wells)	0.57	0.53	9.3	2.9	0.08	0.75	0.01
Mountain R.	1.7	0.40	11	1.6	0.03	0.28	0.001
Peel R.	0.50	0.21	14	0.90	0.02	0.11	0.01
Redstone R.	1.7	0.39	9.3	1.8	0.07	0.47	0.01
Saline R.	1.8	0.41	9.5	1.6	0.07	0.06	0.01
Trout R.	1.1	0.58	9.2	2.5	0.08	0.69	0.01
Willowlake R.	1.8	0.35	9.7	1.4	0.04	0.31	0.01

Table IVa Major mineral constituents detected, ranges of particle size fractions - sand (2mm - 50μm), silt (50 - 2μm) and clay (<2μm) - and ranges of percent weight of shore sediment lost upon ignition at 550°C and lost by treatment with 30% H_2O_2 measured during 1971-72. Mackenzie mainstem rivers and streams.

LOCATION	SAND	SILT	(per cent) CLAY	L.O.I.	LOSS H_2O_2
Blackwater R.	29	52	12	6.1	
Great Bear R. (Brackett R.)	13	40	40	15	6.8
Harris R.	26	48	14	6.7	11
Horn R.	45	31	21	14	3.2
Jackfish Creek	8.7	50	34	7.3	13
Jean Marie Creek	42-50	22-30	21-23	11-19	5.6-7.0
Liard R. (Ft. Liard)	50	38	6.4	7.0	5.2
Liard R. (Mackenzie R.)	31	44	13	11	12
Lower Beaver Creek *	50	26	23	0.50	
Martin R.	62-100	0.00-19	0.00-12	10	8.1
Rabbitskin R.	47-100	0.00-26	0.00-24	12	3.2
Redstone R.	3.3-36	45-79	4.4-16	14-14	1.5
Saline R.	54	29	17	13-16	0.50
Secret Creek	65	8.8	14	7.9	13
S. Nahanni (Virginia Falls)	66	26	0.00	8.3	
Trail R.	100				
Trout R.	66	4.8	7.2	13.3	12.1
Willowlake R.	36-83	4.8-56	9.6-28	4.0	12

* Major Minerals: 1. Quartz 2. Plagioclase 3. Ilite.

Table IV b Major mineral constituents detected, ranges of particle size fractions, sand (2mm - 50µm), silt (50 - 2µm) and clay (<2µm) - and ranges of percent weight of shore sediment lost upon ignition at 550°C and lost by treatment with 30% H_2O_2 measured during 1971-72. Yukon rivers and streams.

LOCATION	SAND (per cent)	SILT	CLAY	L.O.I.	LOSS H_2O_2
Bell R.	64	21	11	5.8	4.1
Caribou Bar Creek	43-100	0.00-33	0.00-12	4.1-8.6	4.2-8.4

Table Va Ranges of concentrations of total carbon, nitrogen, and phosphorous and of carbonate (inorganic) carbon measured in shore sediment during 1971-72. Mackenzie mainstem rivers and streams.

LOCATION	C (milli moles $gram^{-1}$)	CO_3-C	N	P
Great Bear R. (Brackett R.)	1.5	0.22	0.08	0.04
Harris R.	0.93-2.6	0.12-1.0	0.10-0.11	0.01-0.01
Horn R.	12	2.1	0.70	0.02
Jackfish Creek		8.6		
Jean Marie Creek	2.3-5.5	0.04-1.4	0.10-0.24	0.02-0.03
Liard R. (Ft. Liard)	2.2	1.2	0.08	0.03
Liard R. (Mackenzie R.)	2.7	1.5	0.10	0.03
Lower Beaver Creek			7.1	
Martin R.	2.3	1.2	0.09	0.03
Rabbitskin R.	2.0	1.4	0.07	0.01

Table Va	C	CO_3-C	N	P
Redstone R.	3.2	2.4	0.07	0.03
Saline R.	3.0	2.7	0.04	0.01
Secret Creek	1.9	1.3	0.04	0.04
Trout R.	3.0	2.7	0.04	0.02
Willowlake R.	1.5	1.0	0.04	0.01

Table Vb Ranges of concentrations of total carbon, nitrogen, and phosphorous and of carbonate (inorganic) carbon measured in shore sediment during 1971-72. Yukon rivers and streams.

LOCATION	C	CO_3-C (milli moles $gram^{-1}$)	N	P
Bell River	1.2	0.13	0.09	0.02
Caribou Bar Creek	2.6	0.07	0.15	0.03

Table VIa Major mineral constituents detected, ranges of particle size fractions - sand (2mm - 50μm), silt (50 - 2μm) and clay (<2μm) - and ranges of percent weight of bank sediment lost upon ignition at 550°C and lost by treatment with 30% H_2O_2 measured during 1971-72. Mackenzie mainstem rivers and streams.

LOCATION	MAJOR MINERALS	SAND (per cent)	SILT (per cent)	CLAY (per cent)	L.O.I. (per cent)	LOSS H_2O_2 (per cent)
Arctic Red R.		10	60	20	9.4	6.8
Cranswick R.		31	40	21	11	8.3
Great Bear R. (Brackett R.)		100			4.2	
Hanna R.		8.5-32	0.00-40	0.00-16	12	
Harris R.		15-25	40-75	2.0-32	9.0-21	1.5-4.7
Mackenzie R. (Above Liard R.)	1. Quartz 2. Plagioclase 3. Dolomite 4. Chlorite 5. Calcite	36	40	6.0	18	
Martin R.		23-100	0.00-48	0.00-18	11-13	7.9
Secret Creek		12	56	17	24	16

Table VIb Major mineral constituents detected, ranges of particle size fractions- sand (2 mm - 50μm), silt 50 - 2μm) and clay (<2μm) - and ranges of percent weight of bank sediment lost upon ignition at 550°C and lost by treatment with 30% H_2O_2 measured during 1971-72. Yukon rivers and streams.

LOCATION	MAJOR MINERALS	SAND (per cent)	SILT (per cent)	CLAY (per cent)	L.O.I. (per cent)	LOSS H_2O_2 (per cent)
Bell R.		33	42	18	7.9	6.9
Caribou Bar Creek		5.4-59	29-62	1.6-24	5.9-12	7.0-9.2
Eagle R.		41	30	24	7.2	5.0
Lord Creek		59	14	9.2	9.4	18

Table VIIa Ranges of concentrations of total carbon, nitrogen, and phosphorous and of carbonate (inorganic) carbon measured in bank sediments during 1971-72. Mackenzie mainstem rivers and streams.

LOCATION	C	CO_3-C	(milli moles $gram^{-1}$) N	P
Arctic Red R.		9.2		
Cranswick R.	2.3	0.46	0.14	0.31
Great Bear R. (Bracket R.)	2.9	2.7	0.02	0.01
Harris R.	2.9-3.5	0.13-1.0	0.14-0.16	0.01-0.02
Mackenzie R. (Above Liard R.)				0.02
Martin R.	2.7	1.3	0.09	0.02
Secret Creek	3.7	1.4	0.12	0.04

Table VIIb Ranges of concentrations of total carbon, nitrogen and phosphorous and of carbonate (inorganic) carbon measured in bank sediments during 1971-72. Yukon rivers and streams.

LOCATION	C	CO_3-C	(milli moles $gram^{-1}$) N	P
Bell R.	1.7	0.09	0.09	0.03
Caribou Bar Creek	0.20-4.2	0.03-0.15	0.06-0.18	0.01-0.03
Eagle R.	1.7	0.15	0.08	0.03
Lord Creek	2.2	0.14	0.10	0.02
Porcupine R.	2.8-3.4		7.1-8.6	

Table VIIIa Ranges of concentrations of total calcium, potassium, silica, aluminum, titanium, iron and manganese measured in bank sediments during 1971-72. Mackenzie mainstem rivers and streams.

LOCATION	Ca	K	Si	Al	Ti	Fe	Mn
	(milli moles $gram^{-1}$)						
Arctic Red R.		0.56	9.8	3.4	0.10	1.1	0.02
Harris R.	0.66	0.33	11	1.5	0.05	0.64	0.01
Mackenzie R. (Above Liard R.)	0.98	0.33	12	1.6	0.06	0.37	0.01

APPENDIX XII

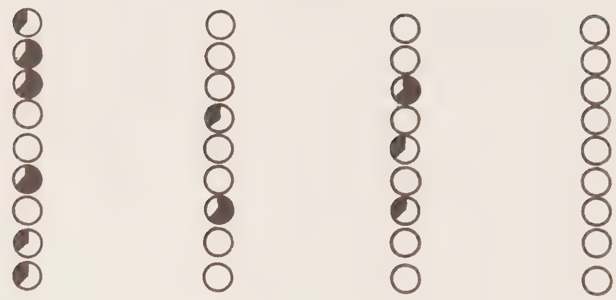
Yellowknife Bay oil spill - Supplementary data, 1972.

Fig. 1 Taxon list of zoobenthic organisms in Yellowknife Bay - July, 1972.

Taxon	Depth 0.5 m disturbed	Depth 0.5 m undisturbed	Depth 2.0 m disturbed	Depth 2.0 m undisturbed
Ostracoda				
Cyclocypris ampla	○	○	◐	○
Cyprinotus glauws	○	◐	○	○
Hydracarina				
Axenopsis sp.	○	○	○	◕
Oxus sp.	○	○	○	◕
Hygrobates sp.	○	○	○	◐
Piona sp.	◐	○	○	○
Trichoptera				
Setodes sp.	○	○	○	◐
Molanna sp.	○	◐	○	○
Tipulidae				
Tipula (*Arctotipula* sp.)	○	◐	○	○
Empididae				
Hemerodromia sp. 1	○	◐	◐	◐
Ceratopogonidae				
Bezzia (*Palpomyia*)	◐	○	○	○
Chironomiidae				
Psectrocladius sp.	○	○	◐	○
Trissocladius sp.	○	○	◕	◕
Heterotrissocladius sp.	○	○	◐	◐
Orthocladiina sp.	○	○	○	◕
Cricotopus sp.	◐	◕	○	○
Thienemannimyia sp.	○	○	◕	◕
Procladius sp.	○	○	◕	◕
Ablabesmyia sp.	○	○	○	◕
Prodiamesa sp.	●	○	○	◕
Cryptochironomus sp.	○	◕	◕	○
Cryptotendipes sp.	○	○	◐	◐
Dicrotendipes sp.	○	○	◐	◐
Parachironomus sp.	○	○	◐	●
Stictochironomus sp.	◐	○	○	○
Demicryptochironomus sp.	◐	◐	○	○
Polypedilum sp.	◕	●	○	○
Chironomidae	○	◐	○	○
Coleoptera				
Agapus sp.	○	◐	○	○
Haliplus sp.	○	◐	○	○
Amphipoda	○	◕	●	●
Nematoda				
Mesodorylaimus sp.	○	◐	○	○

Fig. 1 continued

Oligochaeta
- Iliodrilus
- I. n.s.p.
- Lumbriculsus variegatus
- Limnodrilus udekemianus
- Limnodrilus sp.
- L. profundicola
- Rhyacodrilus sodalis
- N. variabilis
- Marionina



Legend

Number of times taxa occurred in Yellowknife samples

-0
-1
-2
-3

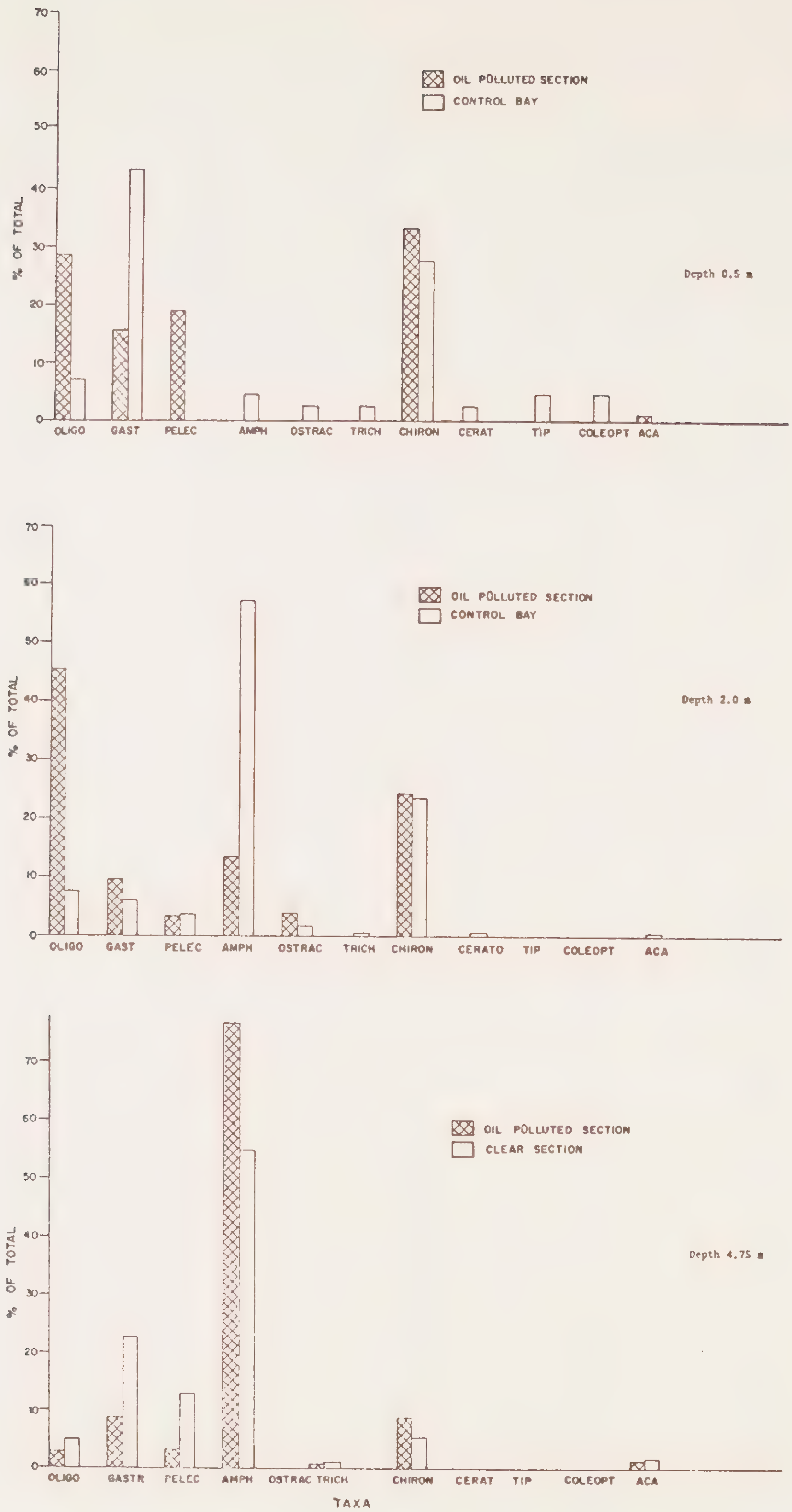


Figure 2: Percent occurrence of Zoobenthos in Yellowknife Bay.

APPENDIX XIII

Supplementary data on Lake 4, Mackenzie Delta, 1971-72

Table I Bathymetry, Lake 4, 5-VIII-72.

Surface Area (A_o)	=	0.653 ha
Maximum depth (Z_m)	=	2.3 m
Mean depth (Z)	=	1.0 m
Volume (V)	=	6462 m^3

Table II Lake 4 - profundal benthos - taxon list.

Insecta	Chironomidae	
		Ablabesmyia
		Procladius
		Tanytarsus
		Chironomus
		Dicrotendipes
		Endochironomus
		Microtendipes
		Parachironomus
		Polypedilum
		Psectrocladius
		Einfeldia
	Chaoboridae	
		Chaoborus flavicans
	Ceratopogonidae	
		Bezzia/Palpomyia
		Bezzia
	Coleoptera	
		Haliplus immaculicollis
Crustacea	Ostracoda	
		Cyclocypris ampla
		Cypria ophthalmica
		Candona acutula
		C. protzi
Annelida	Oligochaeta	
		Peloscolex
Nematoda		
		Mononchus niddensis
		Dorylaimus stagnalis
		Tripyla
		Tobrilus
Mollusca	Gastropoda	
		Gyraulus deflectus
		Lymnaea elodes
		L. stagnalis
		Physa gyrina
		Valvata sincera helicoidea
		V. tricarinata
	Pelecypoda	
		Pisidium idahoense
		P. lilljeborgii
		P. ventricosum
		P. compressom
		P. subtruncatum
		P. milium
		Sphaerium nitidum
		S. lacustre

Table III Lake 4. Profundal benthos annual density and composition.

Date	Density (#/m^2)	Chironomidae	Acarina	Oligochaeta	Nematoda	Gastropoda	Others
		% composition of major taxa					
17.9.71	4088	0.7	0	1.7	0	74.7	22.9
19.3.72	2870	88.3	1.0	0.5	0	10.2	0
21.5.72	1106	67.1	19.0	5.1	2.5	0	6.3
11.7.72	854	41.0	0	8.2	45.9	3.3	1.6
27.7.72	3159	91.5	3.4	0	1.7	2.6	0.8
5.9.72	4172	75.5	4.4	2.3	2.0	2.3	13.5
12.9.72	3766	72.5	7.1	1.9	5.6	12.6	0.3
mean	2859	62.4	5.0	2.8	8.1	15.0	6.5

Table IV Genera of littoral benthic insects in and above experimental NW plot, Lake 4, Mackenzie Delta.

	Surface film			Littoral benthos		
	4.9.72	17.9.72	19.9.72	5.9.72	12.9.72	19.9.72
Chironomidae						
Ablabesmyia	x		x	x	x	x
Procladius	x			x		
Cladotanytarsus				x		
Paratanytarsus		x	x	x		x
Tanytarsus	x		x	x	x	x
Chironomus		x		x	x	x
Cryptocladopelma				x	x	x
Cryptochironomus				x		
Dicrotendipes		x	x	x	x	x
Endochironomus				x	x	x
Glyptotendipes				x		x
Lauterborniella				x		
Microtendipes				x		
Parachironomus				x		
Polypedilum		x	x	x		x
Pseudochironomus	x		x	x	x	x
Psectrocladius			x	x	x	x
Cricotopus				x		x
Orthocladius				x		x
Odonata						
Aeschna		x		x	x	x
Leucorrhinia hudsonica				x		
L. intacta				x		
Libellula				x		
Coenagrion resolutum		x	x	x	x	x
Coenagrion		x	x	x	x	x
Ephemeroptera						
Caenis				x		x

Table IV cont'd

	Surface film			Littoral benthos		
	4.9.72	17.9.72	19.9.72	5.9.72	12.9.72	19.9.72
Trichoptera						
Phyryganeidae sp. 'A'		x		x	x	x
Phryganea				x	x	x
Glyphotaelius				x		
Coleoptera						
Colymbetes groenlandicus				x		
Gyrinus	x					
Ilybius subaenus		x				
Agabus		x	x			
Haliplus immaculicollis	x		x	x	x	x
Hydroporus		x				
Dytiscus emarginalis				x		
Hemiptera						
Gerris buenoi	x					
Microvelia buenoi	x					

APPENDIX XIV

The effect of depth on the colonization of artificial substrates in the Mackenzie and Liard Rivers at Fort Simpson, and the effect of crude oil on the colonization of artificial substrates in the Trail River, 1971-72.

Effect of depth on colonization of artificial substrates.

The results of one month's colonization of artificial substrates suspended at three depths in the Mackenzie River and two in the Liard River at Fort Simpson are summarized in the following table (numbers of invertebrates are means of 2 artificial substrate samplers):

	Depth		
	45-50 cm	1 m	just above bottom
Mackenzie	270	328	44
Liard	214	80	

Maximum numbers of invertebrates occurred at a depth of one meter in the Mackenzie and just under the surface of the water in the Liard. Simuliidae and Plecoptera show the highest per cent occurrences, in that order, for both shallow and one meter depths. Trichoptera are always fourth and Ephemeroptera and Chironomidae alternate between third and fifth. However, taxa from the baskets just above the bottom have the following order: Plecoptera:Simuliidae: Chironomidae:Ephemeroptera:Trichoptera. The fauna of the two shallowest depths can probably be safely considered to be the same. Whether the difference between shallow and deep is real or due to methodological differences in removing the baskets remains to be answered.

Effect of crude oil on colonization of artificial substrates.

The genera and numbers of zoobenthos found on oil-dipped and non-dipped artificial substrates installed in the Trail River are given in Tables I-IV. These results are discussed in the text.

Table I Numbers of individuals in genera of Trichoptera in oil-dipped and non-dipped artificial substrates from the Trail River on August 11, 1972.

GENUS	STATION		
	1	2	2a
	non-dipped		oil-dipped
Arctopsyche	2	9	2
Athripsodes	2	2	7
Brachycentrus	0	0	1
Ecclisomyia	0	3	0
Glossosoma	7	5	4
Hydropsyche	9	58	32
Hydroptila	1	1	1
Lepidostoma	4	9	2
Oecetis	10	17	6
Oxyethira	2	0	0
Polycentropus	0	1	0
Rhyacophila	0	3	0

Table II Numbers of individuals in genera of Ephemeroptera in oil-dipped and non-dipped artificial substrates from the Trail River on August 11, 1972.

GENUS	STATION 1	2	2a
	—— non-dipped	——	oil-dipped
Ameletus	5	0	0
Baetis	2	1	13
Ephemerella	9	19	30
Heptagenia	8	10	1
Paraleptophlebia	0	3	0
Parameletus	3	0	0
Stenonema	18	14	0

Table III Numbers of individuals in genera of Simuliidae in oil-dipped and non-dipped artificial substrates from the Trail River on August 11, 1972.

GENUS	STATION		
	1	2	2a
	—— non-dipped ——		oil-dipped
Prosimulium	0	0	2
Simulium	1	4	325

Table IV Numbers of individuals in genera of Chironomidae in oil-dipped and non-dipped artificial substrates from the Trail River on August 11, 1972.

GENUS	STATION 1	STATION 2	STATION 2a
	non-dipped	non-dipped	oil-dipped
Ablabsemyia	0	1	0
Brillia	1	0	1
Corynoneura	23	30	1
Cricotopus	9	2	59
Diplocladius	1	0	0
Eukiefferiella	10	13	37
Microcricotopus	1	3	31
Micropsectra	0	2	0
Microtendipes	3	1	0
Nilotanypus	8	13	1
Orthocladius or Cricotopus	13	52	416
Polypedilum	6	11	2
Psectrocladius	1	0	0
Rheocricotopus	1	4	3
Rheotanytarsus	56	118	43
Parametriocnemus	0	2	0
Synorthocladius	62	18	2
Thienemanniella	29	31	10
Trissopelopia	6	4	6

APPENDIX XV

Supplementary data on the zoobenthos of

Mackenzie Delta lakes, 1971-72.

Table I. Occurrence and co-occurrence of profundal benthos species in clear, silty and oiled Mackenzie Delta Lakes.

Taxon	Oiled only	Clear only	Silty only	Clear/ Silty	Oiled/ Clear	Oiled/ silty	Oiled/Clear/ silty
Chironomidae	6	8	3	0	4	0	1
Ceratopogonidae	0	0	0	1	0	0	0
Chaoboridae	0	1	0	0	0	0	0
Hemiptera	1	1	0	0	0	0	0
Ephemeroptera	1	0	0	0	0	0	0
Trichoptera	1	1	0	0	1	0	0
Nematoda	0	1	0	1	0	0	0
Oligochaeta	1	2	1	0	0	0	0
Ostracoda	0	7	0	1	0	0	0
Amphipoda	0	0	0	0	0	0	1
Gastropoda	0	11	1	0	0	0	0
Pelecypoda	2	4	0	1	2	1	0
	11	36	5	4	7	1	3

Table II. Profundal Benthos of Mackenzie Delta Lakes.

		Silty		Clear		
	Lake	1	3	5	7	SL*
Insecta	Chironomidae					
	Harnischia	X				
	Procladius	X	X	X	X	X
	Paracladopelma		X			
	Acalcarella		X			
	Ablabsemyia			X	X	
	Chironomus			X	X	X
	Glyptotendipes			X	X	X
	Cryptotendipes			X		
	Dicrotendipes modestus			X	X	X
	Einfeldia			X	X	
	Parachironomus			X		
	Paratanytarsus			X	X	
	Psectrocladius			X	X	
	Endochironomus			X	X	
	Tanytarsus					X
	Polypedilum					X
	Phaenopsectra				X	
	Cricotopus					X
	Zalutschia zalutschicola (= Trissocladius naumanni)					X
	Cryptochironomus <u>cf.</u> blarina					X
	Cladotanytarsus					X
	Ceratopogonidae					
	Bezzia/Palpomyia	X	X	X		
	Chaoboridae					
	Chaoborus flavicans				X	
	Hemiptera					
	Sigara					X
	Dasycorixa johanseni				X	
	Coleoptera					
	Gyrinus				X	

Table II Contd.

		Silty		Clear		
		1	3	5	7	SL
	Ephemeroptera					
	Leptophlebia					X
	Trichoptera					
	Banksiola selina			X	X	X
	Athripsodes				X	
	Grensia praeterita					X
Annelida	Oligochaeta					
	Peloscolex					X
	Limnodrilus hoffmeisteri	X	X	X		X
	L. claparedeiamus	X				
	L. udekensianus			X		
	Lumbriculus variegatus inconstans			X		
Nematoda						
	Dorylaimus stagnalis		X	X		
	Tobrilus			X		
Crustacca	Ostracoda					
	Cyclocypris ampla			X		
	Cypria ophthalmica		X	X	X	
	Megalocypris alba				X	
	Candona acuminata			X	X	
	C. rawsoni			X		
	C. pedata			X		
	C. bretzi			X		
	Cypridopsis vidua			X		
	Amphipoda					
	Gammarus lacustris	X	X	X	X	X

Table II cont'd.

		Silty		Clear		
		1	3	5	7	SL*
Mollusca	Gastropoda					
	Probythinella lacustris	X	X			
	Gyraulus deflectus			X	X	
	G. circumstriatus			X	X	
	Lymnaea atkaensis			X	X	
	L. elodes			X	X	
	Physa jennessi			X	X	
	Valvata sincera helicoidea			X	X	
	V. tricarinata			X	X	
	Lymnaea stagnalis				X	
	Promenetus exacuous				X	
	Armiger crista				X	
	Helisoma trivolvis				X	
	Pelecypoda					
	Pisidium idahoense			X	X	
	P. ventricosum			X	X	
	P. milium				X	
	P. lilljeborgii			X		X
	P. nitidum			X		X
	P. ferrugineum					X
	P. conventus		X			
	P. subtruncatum		X	X		
	Sphaerium nitidum			X	X	
	Anodonta					X

* SL = 'Shell' Lake - oil-polluted for comparison only and not discussed in text.

Shell (Long) Lake is a float-plane base near Inuvik, and receives spilt aircraft fuel, oil, and small amounts of sewage.